SCIENCE

FRIDAY, JANUARY 20, 1911

CONTENTS

The American Association for the Advancement of Science:—
The Relations between Jupiter and the Asteroids: PROFESSOR ERNEST W. BROWN 79

Organic Response: DR. D. T. MACDOUGAL .. 94

Educational and Industrial Efficiency: PRESIDENT RICHARD C. MACLAURIN 101

Scientific Notes and News 103

University and Educational News 106

Discussion and Correspondence:—
Special Committees on Zoological Nomenclature: DR. C. W. STILES. *Facts and Principles:* PROFESSOR SIDNEY GUNN 107

Scientific Books:—
Van Hise on the Conservation of Natural Resources in the United States: W J M. *Chesneau on Theoretical Principles of the Methods of Analytical Chemistry:* PROFESSOR M. A. ROSANOFF 108

Scientific Journals and Articles 112

Special Articles:—
Elliptic Interference in Connection with Reflecting Grating: PROFESSOR CARL BARUS 113

The American Society of Naturalists: DR. CHAS. R. STOCKARD 113

The American Chemical Society: PROFESSOR CHARLES L. PARSONS 114

The American Physiological Society: PROFESSOR A. J. CARLSON 115

The American Mathematical Society: PROFESSOR F. N. COLE 117

The Southern Society for Philosophy and Psychology: PROFESSOR R. M. OGDEN 118

MSS. intended for publication and books, etc., intended for review should be sent to the Editor of SCIENCE, Garrison-on-Hudson, N. Y.

THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

THE RELATIONS BETWEEN JUPITER AND THE ASTEROIDS[1]

THE story of the smaller bodies which form part of the solar system belongs altogether to the nineteenth and twentieth centuries. The discovery of Ceres on the first of January, 1801, followed by those of Pallas, Juno and Vesta, in the next six years, gave promise of a new field for the astronomer. Nearly forty years, however, elapsed before any more were found. The improvements in star maps about the middle of the century enabled observers to detect new objects more easily, so that from 1845 to 1860 over sixty were captured. Since that time scarcely a month but brings one or more to the list, and now nearly 700 are known. But this by no means completes the tale. New asteroids are constantly being recorded and receive a temporary designation and are perhaps observed two or three times. In fact the number of new discoveries has become too great for the few astronomers interested to obtain orbits of sufficient accuracy for future observation. It has become a question whether the search should be continued, and if so what plan should be adopted for the computation of the orbits.

To the student of celestial mechanics these small bodies furnish many interesting problems. The older planets and our own moon have had such thorough attention accorded to the study of their motions, that the outstanding difficulties are almost solely in the last refinements and

[1] Address by the retiring vice-president of Section A, American Association for the Advancement of Science, Minneapolis, December 28, 1910.

the most minute consequences of the laws under which they run their courses. Their orbits differ but little from circles, and for practical purposes the series of terms which represent their motions are easily obtained, even if the process of so doing may sometimes be a lengthy one. Far otherwise is it with the asteroids. Many of their orbits are highly eccentric and inclined at large angles to the plane near to which the large planets circulate. But the most interesting problems are those which arise from the near presence of the second largest member of the solar system, Jupiter, whose mass is but little less than one thousandth that of the sun.

Jupiter, great as it is compared with the other planets, is yet small relatively to the central body which mainly controls their movements. In general its average effect on a body which does not come very near to it must be small. Under certain circumstances, it may cause very considerable deviations for a time, even in planets which do not approach it very closely. Astronomers have generally divided the disturbances of the motion of one body produced by another into two classes, periodic and secular. The latter are properly those which change the motion always in the same sense so that they would ultimately cause a change to another type of motion. As a matter of fact, however, the division is arbitrary and in a strict sense inaccurate. So far as we know, all the disturbances produced in our solar system by gravitation are really periodic, but some of the periods are so long, extending to thousands and ten thousands of years, that it is more convenient in the short space of time during which we desire to know the motion to treat certain of them as secular.

These long period deviations are often of very considerable extent. They may be divided into two classes, "proper" and "accidental." In the former all the bodies which have the same type of motion have the long period terms, for instance, the slow oscillations of the eccentricities of all the planets due to the attractions of one on another are of this type and they arise principally because the masses of the planets are small compared with the mass of the sun.

The accidental terms are those arising from a synchronism of periods. They should be regarded perhaps as a result of the defects of our mode of representing the motion in symbolic form. However this may be, their presence causes a real practical difficulty which must be solved. We regard the motion of each body as having a principal period of revolution round the sun in a circle, with deviations from circular motion due to the eccentricity of the orbit, these deviations having periods which are multiples of the principal period. Thus there will always be some period in the motion of one planet very near to a period in the motion of another planet. When the degree of approximation we require is settled there will only be a limited number of accidental corresponding periods. If the difference between the two periods is small, a term of long period arises, and the amplitude of the oscillation is nearly proportional to the long period (or to the period squared) and it might seem that when the period became infinitely great the amplitude would also tend to infinity. In physical terms the motion would be unstable. It is not so in general. When the amplitude begins to approach very large values the motion may still be stable. If it is, one of two things has occurred. Either the difficulty is a symbolic one, that is, our mode of representing the motion is defective for large oscillations, and the difficulty can be bridged by choosing some other analytical

representation, or the type of the oscillation may completely change; when the latter happens, it is generally necessary to change also the symbolic representation.

A change in the character of an oscillation which does not cause real instability can be illustrated by a simple example. This illustration, while it has no immediate bearing on the question of synchronism, does show the change in the character of the motion which is sometimes produced by a synchronism.

Let us consider the motion of a rod, one end of which is pierced to admit a horizontal axle so that the rod can rotate in a vertical plane. Suppose that the rod is rotating so rapidly in one direction (called positive) that it makes many complete revolutions in a second. There will be slight differences of velocity at various points, differences which can be expressed quite accurately by a single harmonic term. Owing to frictional resistances the speed will gradually diminish. With diminished velocity the difference between the velocities at the highest and lowest points increases in a ratio which varies very nearly in the inverse ratio of the average speed. When the speed has so far decreased that the ratio of the velocity at the top to that at the bottom is very small, we can no longer express the differences of velocity approximately by a single harmonic term, but must include the higher harmonics. At the critical stage when the velocity at the top is just zero, the representation fails. From our knowledge of the physical side of the problem we know that this failure is not owing to the defects of the representation, but that it is due to a change in the character of the motion. The rod ceases to make complete revolutions and begins to oscillate to and fro with diminishing amplitude until it finally comes to rest at the lowest point. There is another side to this example which is important for what follows. The difference between the velocities at the highest and lowest points is continually increasing, but it does not become infinite. At the critical stage it reaches a maximum value and, becoming discontinuous at this point, has its range suddenly doubled. The minima and maxima are nearly equal in magnitude but of opposite signs. The range then diminishes until it reaches the limit zero. The critical point is, of course, a position of unstable equilibrium and then any small force which may be acting, but which could previously be neglected, may determine the character of the future motion.

If we neglect the resistance of the air and imagine that the axle on which the rod is mounted is made to turn in the opposite sense to the original rotation of the rod, the slight friction between the rod and its axle will gradually tend to stop the motion. But when the rod is nearly at rest close to its highest position one of two things will happen; either the rod will begin to oscillate as before, or after the first oscillation it will be carried past the highest point and begin to rotate in the same sense as the axle with increasing average velocity.

On the analytical side we have to notice mainly one point. Before the critical stage the angular motion is expressed by an angle which increases continuously with the time. As the motion gets slower the variations from uniform increase become more and more marked. After the critical stage is passed and the rod is oscillating to and fro, the angle itself varies between two limits which are less than 360° apart, finally settling down to a constant value. If, however, the rod begins to make complete revolutions in the opposite direction, the angle diminishes continuously with the time, and its variations from uniformity

become smaller as the mean angular velocity increases negatively. It is true that we are accustomed to express the small oscillations of a pendulum by means of angles which increase uniformly with the time, but it is the angle of oscillation which is so expressed and this angle varies between finite limits.

I must apologize for insisting at such length on an elementary illustration with which you are all familiar. Though it serves to make clear the types of deviations which Jupiter may induce in the motion of an asteroid, the analogy must not be pushed too far. It fails to illustrate what may happen to a planet when the stage which corresponds to the rod at rest near the lowest point of the circle has been passed. And it takes no account of the numerous short period changes which the planet experiences and which can not be altogether neglected. Moreover, forces may be present which may tend to increase the oscillatory motion, so that after a period of hesitation the planet may be compelled to settle down into a motion which corresponds to a rotation of the rod in the negative direction, and this independently of the minute forces which may determine its motion just after the velocity has first become zero.

These periodic changes, in which the variable is constrained to remain between finite limits, are generally known as librations. The familiar example furnished by the motion of the moon relative to its center of mass is of course a result of the synchronism of its period of rotation about its axis with that about the earth. The delicate balancing of the conditions necessary for a libration makes the term unusually appropriate in the cases of the motions of the asteroids.

All the earlier discoveries indicated that the smaller members of the solar system, which were not satellites of some planet, occupied a more or less well-defined region between the orbits of Mars and Jupiter. But the distribution was by no means continuous. It was soon seen that if the mean periods as then determined were arranged in order of magnitude there were gaps in the list which could not be explained by the law of averages. It was, I believe, Professor Kirkwood, of Indiana, who first pointed out that these gaps existed at or near the places where the periods are commensurable with the period of Jupiter. With the increasing number of planets discovered the discontinuities have become more accentuated. In general, the smaller the two whole numbers which represent the ratio, the wider is the gap. It has been known that such cases of commensurability produced great difficulties in computation and that the ordinary methods failed. The idea was this—near commensurability of a forced period and a natural period produces large deviations, growing larger the more closely the whole number ratio was approached. It was thought that when the ratio became exact the deviation would be infinite, or in physical language the orbit was unstable. But the deviation, at any rate so far as at present known, does not tend to an infinite limit. There appears to be a maximum value which can not be exceeded, and if the planet is so started that this maximum is passed, the ratio of the two periods becomes exact and oscillations about this exact ratio occur. The natural period becomes a forced period. The analogy to the case of the rod is evident.

As early as 1812 Bessel had pointed out that the periods of Jupiter and Pallas are very nearly in the ratio of 7 to 18 and that the attraction of Jupiter must maintain this exactly, that is, the deviations from it would be oscillatory and not secular. New-

comb invoked the same idea to combat the opinion that instability was the cause of the gaps in the distribution of the asteroids. In a word, the oscillations become librational and have finite limits, or in physical terms, the motion is stable. Thus instead of causing an absence of asteroids at the positions of commensurability, with this idea the action of Jupiter should rather tend to increase the number, since a definite proportion of those very near would be compelled to librate about the exact ratio. It is not clear to what extent the published elements are dependent on the terms of very long periods, but the main issue is not affected; none of the known asteroids in the principal lacunæ appear to librate.

In order that you may see the extent of the inequalities in the distribution I shall throw upon the screen a chart (Fig. 1) in which the abscissæ represent the mean periods in days and the ordinates the number of planets with those periods. Each vertical division represents ten days and the number of planets whose periods fall

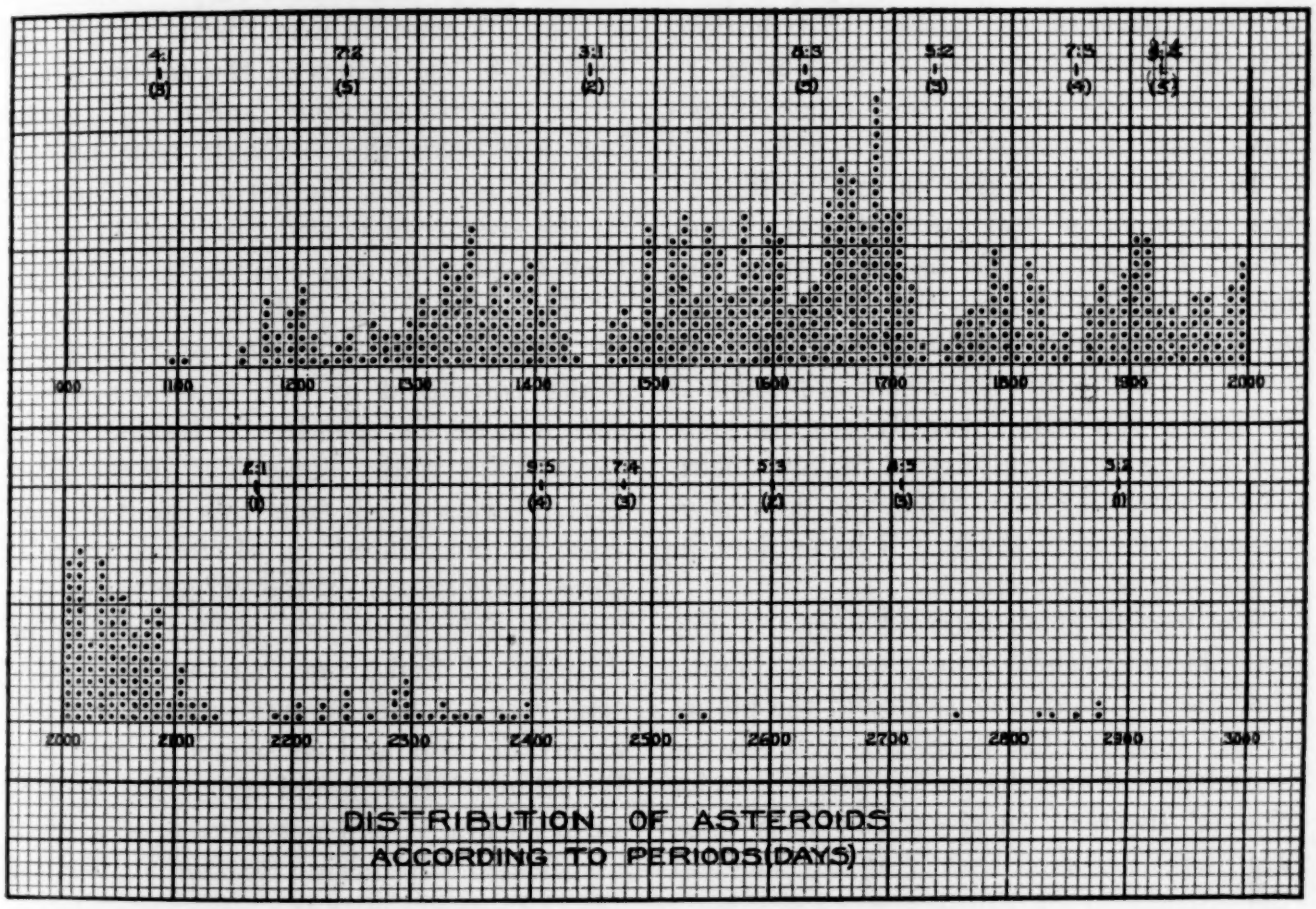

FIG. 1

within any division is shown by the height of the curve at that place. There are about 630 asteroids represented. The curve falls to zero at 2,160, 1,850, 1,730 and 1,440 days and there are less well marked minima in other places. Now these four minima include the places where the periods are in the respective ratios of 2:1, 7:3, 5:2, 3:1 to the period of Jupiter. There are also indications of minima at the places where the ratios are 8:3, 7:2, 9:4. These are all the whole number ratios within the range with a denominator less than 5.

I am going to speak more particularly

of the gap at the ratio 2:1, this being the most extended of all. Here there are no known planets with periods between 2,120 and 2,204 days; the exact ratio is 2,166, not very far from half way between the two sides of the gap. The comparatively few planets on the outer side of the gap may be a consequence of the general distribution, but the sudden increase in the number on the inner side suggests that other causes have been at work.

In attempting to give an explanation of the phenomena by gravitational forces alone, I must on this occasion omit any mathematical discussion and simply lay before you the main results at which I have arrived. Until this discussion is published in detail, you will naturally reserve your opinions as to the validity of the argument. The reasons for presenting the results in advance of the methods will be evident in the course of my remarks.

The motion of an asteroid near the critical places depends mainly on two quantities, the apparent eccentricity of the planet at any time and the difference between the actual period and the period which is twice that of Jupiter. In the theory both these are quantities such that if at any moment the attraction of Jupiter were suddenly annihilated, the asteroid would continue its motion in an elliptic orbit round the sun with this period and eccentricity. They are thus determined by the position and velocity of the planet at the moment. The attraction of Jupiter causes the temporary period and eccentricity to vary and it is the variations of those two quantities that are the main factors. Now the equations which I have obtained give the principal parts of these two quantities in the form of the square roots of variable functions. In order that they may be real these variable functions must always be positive. One of two things must happen. Either the variability of the functions is forced, that is, it is independent of the motion of the asteroid, or it is free. In the latter case the motion of the asteroid is limited. Under certain general conditions it has long been known that the equation giving the period is to a large extent free so that the asteroid may librate or not, according to the values of the constants entering into the equation, and there is nothing to prevent the constants from having such values. But the period also depends on the eccentricity, and the possible variations of this quantity can not be neglected.

The eccentricity and the difference of the actual period from that of Jupiter are really connected by two equations which can not be independently treated. The eccentricity is also dependent on the short period terms which from this point of view may be considered as of forced period, since the periods of the larger terms are very nearly multiples of the period of Jupiter. I find from this that the eccentricity can not permanently remain below a certain limit and consequently that if a libration of the period about the critical ratio occurs, it can not have a very small amplitude. Referring to the analogy of the rod, we discover the presence of forces which prevent the angle of oscillation of the rod to and fro from descending below a certain finite value. The oscillation can not become infinitely small. This result is in agreement with a theorem proved by Poincaré that no periodic orbit at such a critical place exists.

Reducing to numbers, I find that the lower limit of the slow variation of the eccentricity for an asteroid just before it reaches the critical stage between libration and non-libration is about one twentieth and that at some time it must become as large as one seventh. If there is an asteroid which has passed this stage and is

librating, the upper limit of the eccentricity is at least one fifth. Thus at some time the asteroid must have a comparatively large eccentricity. These large changes in the eccentricity take place very slowly. Hence the asteroid will during one interval perform many revolutions round the sun in a nearly circular orbit and during another interval many revolutions in a quite eccentric orbit.

It has been mentioned that these large variations of the eccentricity are of very long period—the same as that of the libration—and that they increase with the extent of the libration. One may regard the asteroid as slowly extracting energy from Jupiter (or losing it to Jupiter) until it has accumulated (or lost) a maximum amount, when the reverse process takes place. Jupiter, owing to its immense mass in comparison with that of the asteroid, will not have its motion sensibly altered by the loss or gain. If the type of motion changes when this loss or gain is near a maximum, the asteroid may in future so move that the energy never returns to its original source. The type must then be unstable.

In my discussion all powers of the eccentricity but the lowest have been neglected. This omission prevents us from obtaining a proper representation of the motion when the eccentricity has risen to so large a value as one fifth, and it is to be remembered that this is the lowest maximum which any librating asteroid can have.

If we take into account higher powers of the eccentricity, it is seen that the extent of the variation must be increased to a considerable extent. I have not so far been able to obtain numerical results beyond this stage. The indications are that the eccentricity increases so much at some time that the stability of this type of motion is threatened and that the asteroid is compelled to take up some other type which is more stable.

Although the facts I have stated do not furnish a proof that librations round the ratio 2:1 can not exist, they at least indicate the direction in which stability becomes doubtful. The usual analytical representation, which is possible for moderate librations of the period, fails where the eccentricity becomes very small or great, and the failure is partly due to the short period terms. The question which requires solution is whether the failure with large eccentricities is merely a defect of the mode of representation, or whether it is due to actual instability. My own impression is that the limits of stability of libration about the principal ratios are so near together, that the chance of an asteroid lying between them is very small. This impression is, however, not independent of the observations. There are no known asteroids which perform librations round the ratio 2:1 and there are none which approach libration very closely. The lacuna in the distribution doubtless admits of other interpretations, but the framing of hypotheses to explain it must properly await a more complete discussion of the consequences of the law of gravitation.

The distribution of the asteroids on either side of the gap furnishes certain tests. The theory indicates that asteroids which initially had large eccentricities are more likely to librate than those with small eccentricities. If the large eccentricities, as I believe, tend to become unstable, it follows that the gap must be wider for them than for the small eccentricities. The next slide (Fig. 2) shows the distribution of eccentricities greater and less than one fifth, round the ratio 2:1. It shows also the distribution by differences of .05 of the eccentricities above .20. The tendency of the asteroids to be more distant from the

gap as the eccentricities increase is very noticeable.

Again, according to the theory of a number of asteroids started at various times with the same eccentricity and with periods which bring them near the ratio on the inner side but not such as to allow them to librate, we shall at a future time be more likely to find the values of the eccentricity large at a distance from the gap and small near the gap. The reverse would occur with asteroids on the outer side. The observations confirm this result in a marked degree on the inner side. The number of known asteroids on the outer side is too small to furnish a test, but if the observed distribution is typical of the real distribution the theory would be confirmed. The need of more asteroids, especially on the outer side, is evident.

That these peculiarities are not consequences of the general distribution of the large eccentricities will appear from the next slide (Fig. 3). It will be seen that there is a notable deficiency near to the gap and that this deficiency is much more marked than the general distribution would lead one to expect.

Further support is derived from the inclinations. With the ratio 2:1, there should be no very noticeable difference in the distribution of large and small inclinations round this gap, and the next slide (Fig. 4) shows this. The curves for i greater than 10° can be compared with those for i less than 10° and also with those for each 5° greater than 10°. It is seen at once that there is no selection of the large or small inclinations. The distribution for large inclinations appears to follow the same general law as the distribution for small inclinations. If we refer back for a moment to the slide giving the distribution of the eccentricities, it will be seen how different the two distributions are.

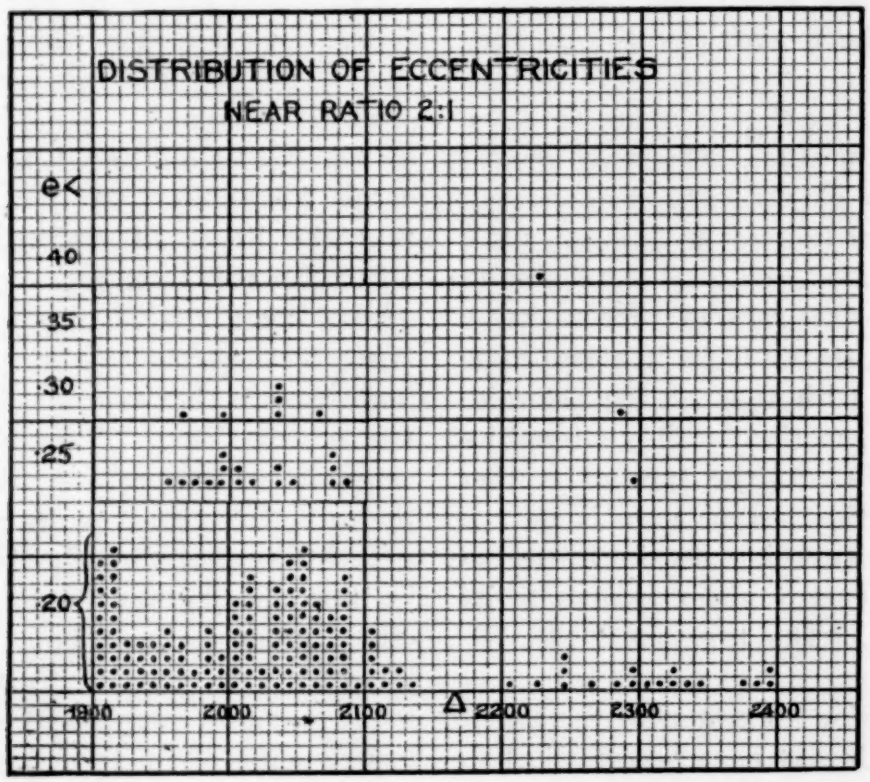

Fig. 2

I have hitherto spoken solely of the ratio

2:1. Similar results can be obtained concerning the distribution round the other ratios, but these I must dismiss in a few words, mainly because the details have not yet been worked out. It can be stated, however, that the inclination can not in general be neglected when the difference between the two terms of the ratio exceeds unity. Nevertheless, the general result an eccentricity greater than one fifth. This is nowhere more strikingly illustrated than at the values 7:3 and 9:4. There is a large maximum of small eccentricities between these ratios, and only three asteroids with eccentricities so great as twenty-five in the same space. A similar phenomenon is observable between the ratios 7:2 and 4:1.

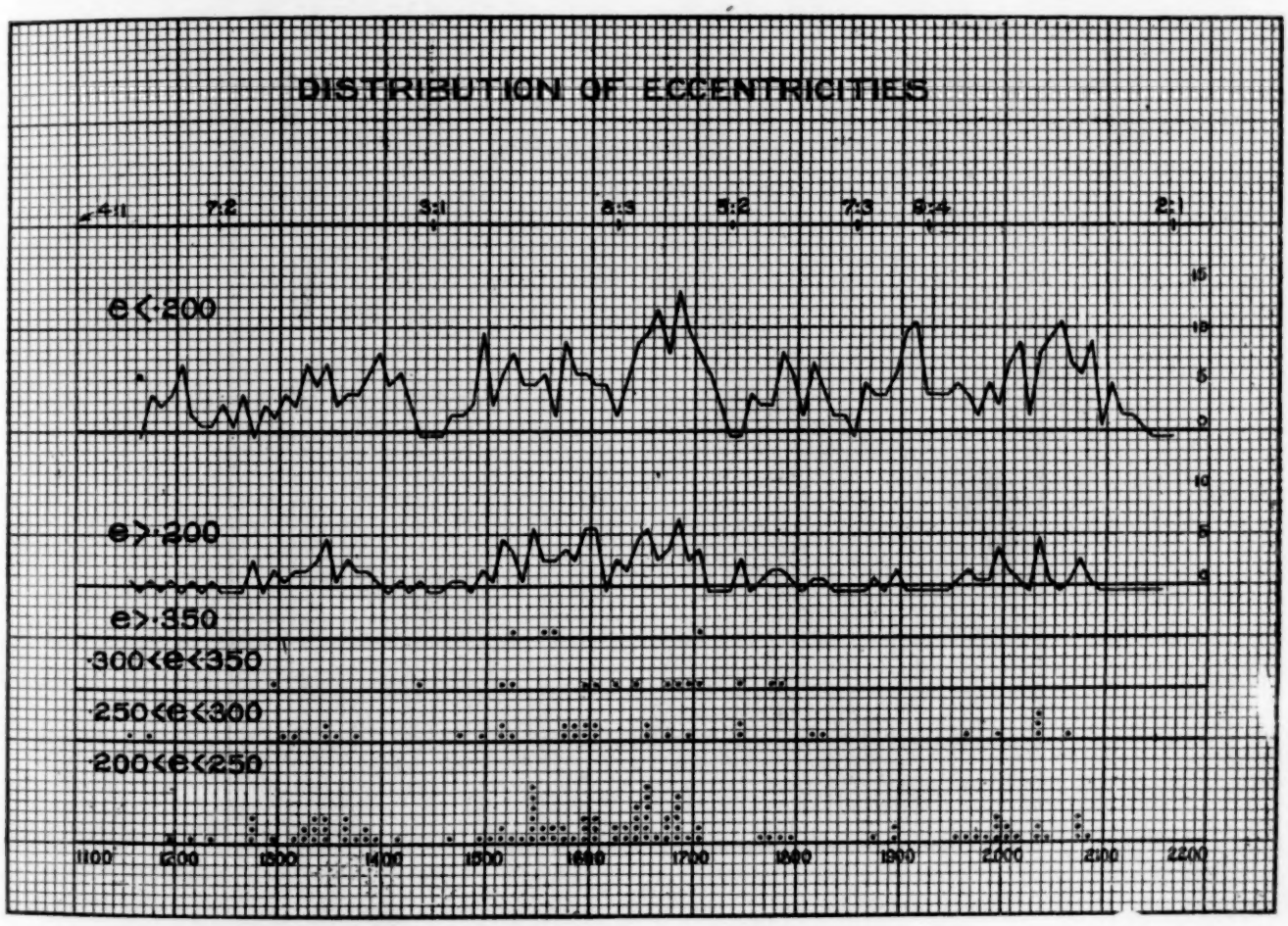

FIG. 3

holds that larger eccentricities are more likely to be absent very close to the gaps than smaller ones.

Referring again to the chart of the general distribution of the eccentricities (Fig. 3), we notice that no one of the ratios, even when the difference of the two terms is 5 (corresponding to a libration with a coefficient depending on the fifth power of the eccentricity), has a close asteroid with

The application of the theory to the satellites and rings of Saturn, though not within the title of my address, can not well be passed over. It is now known that the mean periods of the revolutions of Titan and Hyperion round Saturn are exactly in the ratio of 4:3 and that the actual periods librate about this ratio. The case is quite similar to that of a ratio 2:1. But here the relative disturbing force is much

smaller and the variations of the eccentricity due to this libration are also much smaller. There is, in consequence, less tendency toward instability due to this cause and in fact the numbers do not indicate such a phenomenon. The eccentricity does not rise very greatly in value.

The divisions of the ring system admit of an explanation if we suppose them to consist of clouds of small bodies subject mainly to the attraction of Saturn and of its satellites. A body on or near a critical radius will experience considerable variations of eccentricity which are of long period. A narrow ring of these bodies will therefore be moving in ellipses of different eccentricities which vary for the different bodies much more than for bodies not near this ring. Hence the range of distance of the bodies composing the narrow ring will be spread out much more than for other rings of the same width. At any given time the number of large eccentricities will on the average be much greater than the number of small eccentricities. On both accounts the number of bodies visible at any one time will be least on the critical radius, rise to a maximum on each side of this radius, and then diminish to the average distribution. Thus we get a ring darker than the average between two rings brighter than the average—a result which tends by contrast to increase the apparent difference in illumination.

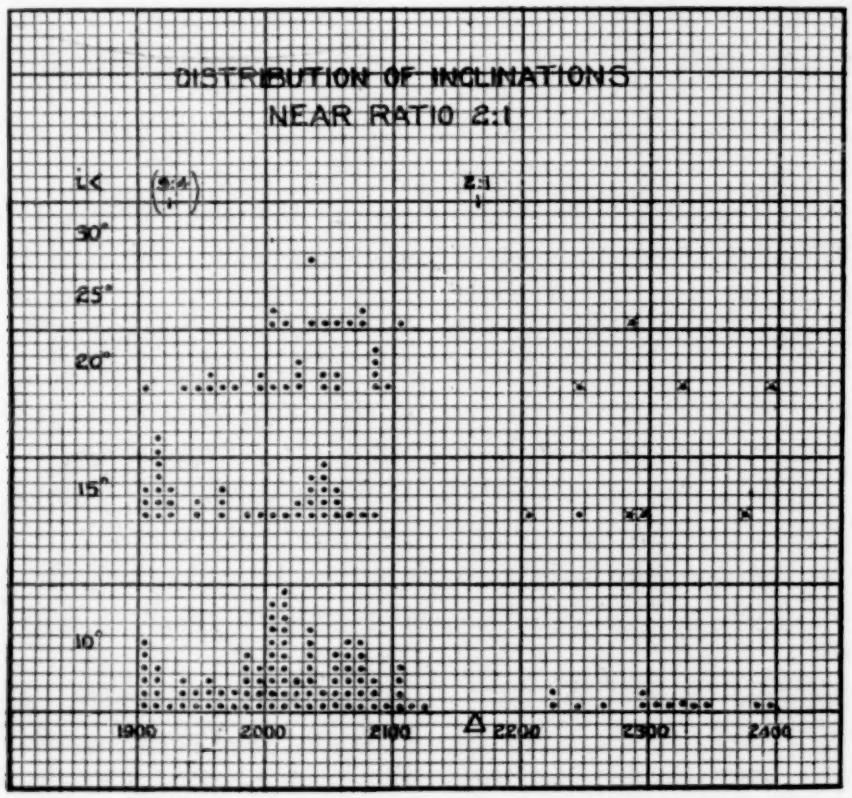

Fig. 4

Another result of this variation of eccentricity may be mentioned. Observation shows that the apparent form of the rings is very nearly circular. It would seem that the orbits of the separate bodies must have small eccentricities in order to avoid collisions in which the velocities differ considerably. Near a libration region the eccentricities can not remain very small. In the course of long periods of time it would result from this that encounters have taken place which changed the velocities of the

colliding masses sufficiently to cause them to pass away from the region of libration. Such collisions may affect the motion in two ways. They may increase the extent of the libration so that the body passes outside of the limits within which librations are possible, or they may at the time diminish the extent of the librations so far that the lower limit of the eccentricity at which librations can be maintained is reached. In either case the body escapes from the region of libration and describes an orbit at an altered mean distance and with a period whose difference from the exact ratio never becomes zero. Thus while the apparent divisions of the ring are not directly caused by the instability of the librations, they are partly caused by perturbations of large amplitude and perhaps also by the results of collisions arising from those large perturbations.

I have hitherto spoken of the effect of Jupiter's attraction on certain groups of the asteroids. A little space must be devoted to the phenomena which are caused in the distribution of the perihelia and nodes of the approximate ellipses in which the asteroids move.

When the orbits of but fifty of the asteroids were known it was noticed that the positions of their perihelia tended to group themselves round the perihelion of Jupiter. A similar phenomenon appeared, though not in so marked a degree, with their nodes and the node of Jupiter. Newcomb proved that the groupings were consequences of the attraction of Jupiter. His explanation, briefly stated, amounts to this. Jupiter causes the perihelia of the asteroids to revolve very slowly round the sun; some of them will librate about the perihelion of Jupiter. In the former case the rates of motion of the lines which join them to the sun are least when these lines are crossing the perihelion of Jupiter, and most rapid when crossing the aphelion of Jupiter. Hence at any given time we are likely to observe more asteroids whose perihelia are near that of Jupiter than asteroids whose perihelia are in other positions. Asteroids whose perihelia librate must be comparatively few in number. The variations of the eccentricity follow the same law. With the nodes and inclinations the effect is less marked. In the latest published investigation by von Brunn, who followed Newcomb's methods with 400 bodies, the explanation is confirmed. The chart (Fig. 5) which is before you on the screen shows the extent of the variations. It is formed with 630 asteroids. The points joined by a continuous curve represent the numbers of asteroids whose perihelia lie in the twelve divisions into which the whole circumference has been divided. The points joined by a dotted line represent the average eccentricity of those asteroids whose perihelia lie in the corresponding divisions. Below are placed the letters *J*, *M*, *E*, *S*, representing the positions of the perihelia, and the letters *J'*, *M'*, *E'*, *S'*, representing the positions of the aphelia of the planets Jupiter, Mars, the earth and Saturn. The two upper charts show the results for the first 300 and the last 330 discoveries, and the lower chart the whole 630. The effect of Jupiter is quite clear. The traces of the other planets are doubtful. It is true that there is a distinct minimum of the perihelia at the group 10 which contains the aphelia of Saturn and the earth and that it is present in all three charts. But there is no corresponding rise at the perihelia, or at any rate the rise is doubtful.

The features of the distribution which are the same in the earlier and later discovered planets can, without much danger of error, be laid aside as consequences of the attractions of the sun and planets.

But there are certain differences which call for special notice. The minima of the perihelia and eccentricity which occurs in the group 7 with the first 300 asteroids occurs in the group 6 with the last 330 asteroids; the displacement does not appear to be accidental. But the most remarkable difference is the greater range between maximum and minimum with the later discovered and presumably smaller bodies with the earlier ones; this difference is observable in both the perihelia and eccentricity curves. Each ordinate of the curve which represents the perihelia in the second chart should, of course, be diminished by one eleventh of its height, for strict comparison with the first chart, on account of the total numbers of planets used; but this does not materially affect the observation. The range is greater by nearly 50 per cent. for the perihelia and by nearly 80 per cent. for the eccentricities. Is this a relic of the initial conditions or the effect of some force other than gravitation, for example, light pressure or the impact of material particles entering or leaving the solar system, in which the mass of the asteroids affected will play some part? There is here a wide

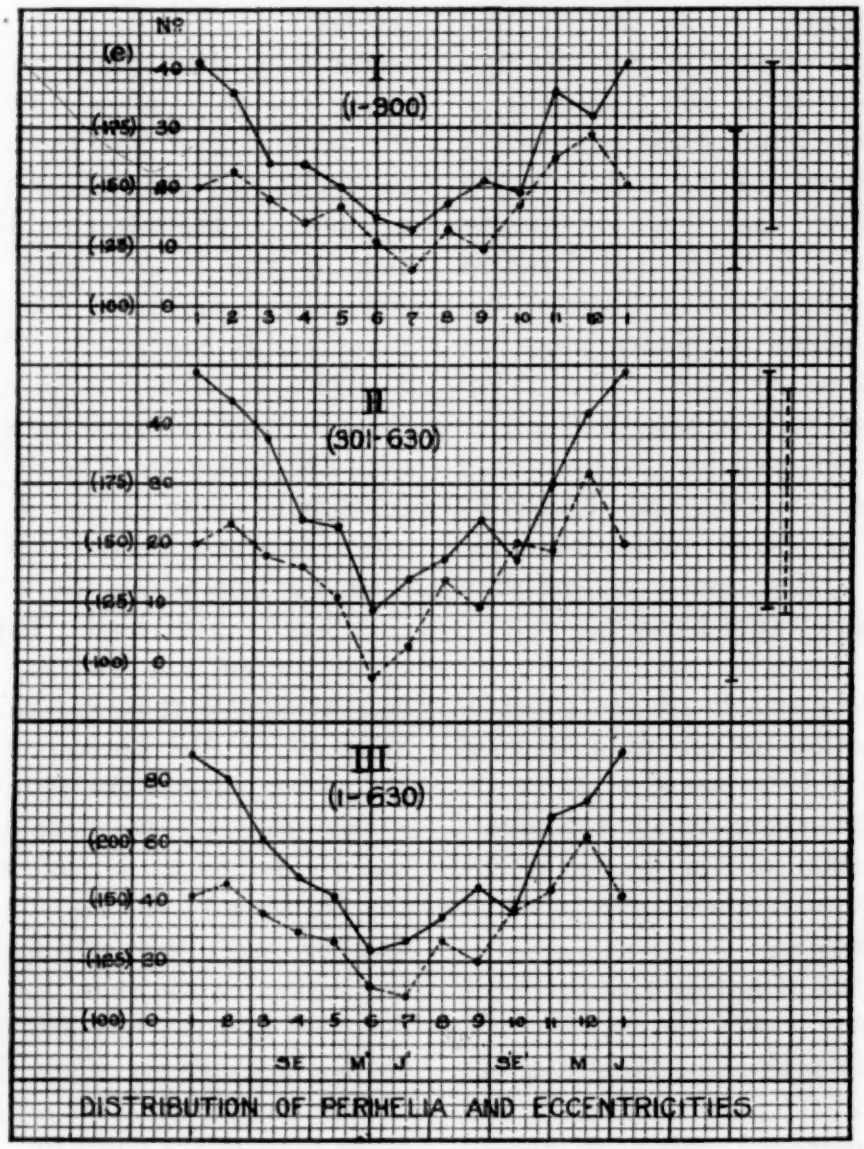

Fig. 5

field for speculation which I shall not attempt to enter this afternoon.

I have hitherto spoken of asteroids which belong to the main group. Others are scattered either singly or in small groups at quite different distances from the sun. Eros, whose orbit lies within that of Mars, is so well known owing to its value for the determination of the parallax of the sun, that it needs only a passing mention. A small group of five asteroids just inside the mean radius at which the period is two thirds that of Jupiter, is of interest as an illustration of the features of those asteroids the large perturbations of which depend on the first power of the eccentricity. As at the place where the ratio is 2:1, the planets are on the inner side of the gap. It is, of course, not possible to draw any conclusions from so small a number.

But the most remarkable illustrations of the problem of three bodies are four small asteroids which have been found within the last five years. Before that time the period and therefore the mean distance from the sun of every known asteroid were less than those of Jupiter. In February, 1906, Wolf observed a body whose velocity appeared to be unusually small and, in the course of a few observations, it was seen that its orbit could not be very distant from that of Jupiter. Charlier suggested that it might probably be an illustration of one of the two cases in which the problem of three bodies can be solved without approximation. Long ago Laplace proved that if three bodies be placed at the corners of an equilateral triangle and started revolving round their common center of mass with a properly adjusted angular velocity, they would continue to do so indefinitely. The triangle remains equilateral and each body describes an ellipse with the center of mass as a common focus. Further, it has been proved that, provided the masses satisfy certain relations, the motions are stable, that is, small oscillations about the triangular positions would not involve the ultimate loss of the type of motion; the triangle would always remain nearly equilateral. As the mass of the asteroid is so small that it may be neglected, the condition for the stability of small deviations is that one mass shall be at least twenty-five times the other; since the sun is over 1,000 times as heavy as Jupiter the condition is well satisfied. There seems to be no doubt that the theory is a correct explanation of the facts. In the intervening years three more asteroids with similar orbits have been discovered. Of the four now known, three are near the point 60° in advance of Jupiter, and one is near the point 60° behind. The mean distances of all four from the sun differ but little from that of Jupiter.

If we examine the orbits of these asteroids on the hypothesis mentioned, namely, that they are merely deviations from the triangular solutions, we have to admit at once that the deviations can not be considered very small. One of them may move as far as 17° away from the mean position as seen from the sun, and a question naturally arises as to the permanent stability of such large deviations. The periods of the oscillations must be very long, not less than 150 years, so that we can not hope to settle the question by direct observation.

These oscillations may be regarded as librational. Bodies well beyond the orbit of Jupiter will revolve around the sun more slowly than that planet, those inside more quickly, and between the two we get a region in which the mean period may be the same. There may then be librations about this mean period which carry the body first inside and then outside the orbit of Jupiter. Referring back to what has

been said concerning the stability of librations around the ratio 2:1, we might be tempted to conclude that the stability of these new asteroids would be still more doubtful. This is not so. When the mean period is the same as that of Jupiter, the librations are very nearly independent of the eccentricity and inclination unless these are very large; and conversely, the latter are but little dependent on the librations of the mean period. It is the only case in which this independence occurs. The conditions governing these librations are so different that a separate investigation of them is necessary. I had hoped to lay before you the results which I have so far reached in determining the possible motions of asteroids which circulate with the same mean period as Jupiter. In order to do so it would be necessary to exceed greatly the time allotted to me. I must content myself with the remark that much larger deviations from the triangular positions appear to be possible and that these may become so extended that a single asteroid may go round both triangular points, passing from one to the other on the opposite side of the sun from Jupiter, and yet not at any time approach very closely to the planet. While describing such an orbit the distance of the asteroid from the sun would vary but little.

In conclusion, a few words must be said concerning the present condition of the observational material and its future needs. There are about 680 bodies whose orbits are more or less well defined. We have seen that the distribution is by no means uniform. With the number on hand we have perhaps sufficient material to determine the general law which governs the arrangement of the orbits. This law is, however, only one of the problems which the system presents. The student of celestial mechanics needs more asteroids in special regions. Reference has been made to the abundance of known orbits on the inner side of the gap which corresponds to twice the period of Jupiter and the lack of material on the outer side. Every asteroid added to those very near the gap will be welcome, but there is a real need for more on the outer side. In any case new bodies whose periods are close to this ratio should be observed until the eccentricity and inclination can be obtained with moderate accuracy. In the course of the search it is possible that one may be found which is within the narrow limits of stability (if the distance between these limits is not zero) of libration. At every opposition a few observations of all the known asteroids near the gap should be made, so that the orbits may be verified and the long period terms compared with theory. It will perhaps be advisable to limit the number of asteroids chosen for continuous observation. If so, a selection can be made which will give types of small, moderate and large inclinations and eccentricities.

A reference to the general chart of distribution of the mean periods will indicate what observational material is needed at the other gaps. Aside from the asteroids whose periods have the features which I have just described, every new discovery of a very large eccentricity of inclination should be retained. I would suggest that eccentricities above three tenths or inclinations to the orbit of Jupiter above 20° would perhaps not unduly tax the capacity of those observers who have made and are making valuable additions to our store of knowledge of these bodies.

Finally every asteroid whose period indicates that it is outside the main stream or near its edges should not be lost. More particularly the search might be directed towards the discovery of bodies having the same mean distance as Jupiter, but with

librations more extended than those of the four at present known. As such bodies are moving most slowly when farthest from the triangular points the search would have greater chances of success within twenty-three degrees to thirty-five degrees of Jupiter on either side, or nearly in opposition to Jupiter. These three areas are nearest to the earth at different times of the year.

Another practical problem is presented by the computation of the orbits. This is mainly a matter of expense so far as the ordinary asteroid is concerned, and one way of meeting the difficulty was shown by Watson, who endowed those discovered by himself. We need not, however, demand that explorers should be responsible for looking after their own discoveries. The asteroids of each type of motion form a group which it would be most economical to treat together if at any time a fund were obtained for the development of the problem. For the present, ephemerides sufficient to identify each body will serve. When a reasonable number of accurate observations, extending over a considerable period of time, has been obtained, the comparison of the observations with theory will be of interest to students of celestial mechanics, and the rest of the work will take care of itself.

In particular, the Trojan group revolving at the same mean distance as Jupiter and at present consisting of the four bodies, Hector, Achilles, Patroclus and one as yet unnamed, will not suffer from neglect. They appear to show one, perhaps the main, stage of transition from bodies superior to the orbit of Jupiter to those inferior to that planet and possibly to those which have become his satellites. Their separate paths of motion are interesting to the mathematician, but even more so to the astronomer, since they appear to indicate a new set of periodic orbits in the problem of three bodies. The remarkable series of families of such orbits obtained by Sir George Darwin has shown how far such an investigation may lead. A single family may have several types. Those which I have described appear to belong to perhaps two families at the most, but nevertheless the extent of the work necessary to discuss them is very considerable, and the mathematical portion of it is by no means simple. They may be peculiar to systems like our own. The work of Sir George Darwin will doubtless have applications to multiple systems of stars, the observational material of which is being rapidly gathered by means of the spectroscope, the heliometer and photographic plate.

Theories as to the mode of formation and development of our solar system will, I believe, receive some assistance from these orbits of transition. If I have not touched on such questions it is not because the temptation to do so was not present. Such matters, however, require an extended discussion under various hypotheses. As Brodetski has shown, different hypotheses concerning the nature of possible resisting media lead to quite different results. My main object has been to attempt to set forth certain actual and possible types of motion within our solar system at the present time in such a manner as to indicate in what direction the theorist and the observer can best act in cooperation. The observer, now that the mass of accumulating material threatens to become too great for permanent record, needs assistance from the theorist so that he may direct his energies into the most useful channels, and not less does the theorist need the help of the observer so that his results may receive confirmation and that he may obtain suggestions for future investigations.

ERNEST W. BROWN

ORGANIC RESPONSE[1]

Recent events in the field of evolution comprehend a number of movements and accomplishments of extraordinary interest. The rediscovery of the facts of alternative inheritance, the formulation of the concepts of equivalent, balanced, paired or differential characters, the results of statistical studies of variability, the analyses of species of various constitution by pedigree cultures, in which the value of fertilization from various sources is carefully measured, the distinction of the biotype or genotype as a hereditary entity, the recognition of the possibilities in the action of pure lines within a specific group, the cytological contributions of fact and forecast upon the physical aspects of heredity, and lastly the presentation of the facts and allowable generalizations identified with the mutation theory, comprise a series of advances, of accretions to knowledge, furnish a broadened foundation for biological science and disclose additional possibilities in all lines of experimental research with living things, besides opening up new realms for speculative thought and stimulating the scientific imagination to renewed fruitfulness.

The pressure of undisciplined evidence bearing upon almost all phases of evolution has awakened a freshened chorus of voices crying the virtues of special interests and extolling the sufficiency of theories dignified by age and more or less weighty with authority. Those busy with vitalism of various patterns have spun a moiety to mend the breaks in the fragile web of their gossamer tissue made by the impact of new facts. Isolation and geographical distribution have again been elaborated to account for all differentiation and what their exponents are pleased to term speciation. The anticipatory formation of structures in a rudimentary condition with a long prefunctional progress, guided by the morphological possibilities and actuated by internal impulses, has again been offered to us, fortified by some facts and much clever logic, in such manner as to avoid most of the serious objections offered, except those of physiological morphology.

Natural selection with diverse meanings and manifold implications, has been made to explain development, differentiation and general evolutionary progress, and the tumult is still great about the idea of mutation. Undeniable occurrences of saltatory changes in hereditary lines are numerous and well known, yet it is probable that the importance of mutation as a general procedure varies in different groups of organisms and certain that many shades of opinion as to its exact part in the evolution of living things will always be held.

The situation with regard to the theory which predicates direct adjustment of the organism, quickly or slowly, as the case may be, to environic factors, and the full inheritance of the alterations constituting such variations is far more serious. The various corollaries of this theory have the force of a certain obviousness, its assumptions have been of ready service to the systematist and biogeographer, and its conclusions have long been tolerated in the absence of decisive tests which are not to be easily made or readily carried out. The time has now arrived, however, when the claimants for Neo-Lamarckianism and all of its conclusions must show cause for its further consideration, or else allow it to drop from the position of being seriously taken as a possible method of evolutionary advance. That no subject is the center of a wider interest is amply demonstrated by

[1] Abstract of presidential address, Society of American Naturalists, Ithaca, New York, December 29, 1910. For full text see *American Naturalist* for January, 1911.

the numbers of recent contributions which may be cited. The positive advance implied is so marked as to justify this discussion within two years of the time when the entire matter was presented comprehensively in connection with the various Darwin anniversary programs.

It is unanimously agreed that organisms, plants as well as animals, change individually in aspect, in form and structure of organs, in functionation and habit as they encounter swamps, saline areas, gravelly uplands or slopes, climatic differences identifiable with latitude or elevation, and other physical and biological factors. It is assumed that these somatic alterations are accommodative and adaptive, making the organism more suitable for the conditions which produce the changes. Such an assumption is an over-reaching one. Any analysis of the changes which an organism undergoes after transportation to a new habitat will disclose one, or a few alterations which might be of advantage in dealing with the newly encountered conditions, but with these are many others, direct, necessitous, atrophic or hypertrophic as to organs which have no relation whatever to usefulness or fitness. Further, a critical examination fails to disclose any theoretical considerations or any actual facts which would connect inevitably the somatic response with the nature of the excitation, outside of the specialized tropisms in which specific reactions are displayed. Even in these the adjustment is of such nature that a mechanism specially responsive to contact, tendrils, for example, responds in the same manner to temperature variations, to which the movements are in no sense accommodations or adjustments.

With regard to the more obvious and direct responses of organisms to altered environment, the records of the operations of the horticulturist, the agriculturist and the breeder as to the behavior of crops, plants and domestic animals, when transferred from one habitat to another, are rich in information. The greater part of such data is the result of observations which do not comply with the ordinary requirements in the avoidance of error so that strict comparisons as to the behavior of organisms under the conditions of various habitats are impossible, but the literature yields many suggestions for experimental research, and the simple generalization that the direct effects of climatic complexes on the seasonal cycle, and upon color, or structural features of the individual, may be repeated or carried over two or three generations, in a habitat where the specific causal combinations are lacking.

Although organized with due regard to the requirements of strict experimentation, the lowland and alpine cultures of plants by Nägeli and Bonnier offer us nothing more decisive than the above. Likewise many experiments dealing with the responses of organisms to selected agencies have obtained nothing but negative results, even when artificial selection was employed to accentuate or perpetuate the feature constituting the reaction.

Buchanan working with *Streptococcus lacticus* finds that phases of fluctuating variations of certain features induced by external exciting agencies may not be fixed and are not transmissible. Jennings' cultures of paramœcia were carried through hundreds of generations with no progressive action in fluctuating variability, while the organism, as a whole, was strongly resistant to all kinds of environic influences: actual alterations were extremely rare. Most of the supposedly acquired characters disappeared in two or three generations by fission.

In the experiments of Sumner mice reared in a warm room were found to differ con-

siderably from those reared in a cold room in the mean length of the tail, foot and ear, and the differences were transmitted to the next generation. The differences may be reasonably designated as being directly individual and somatic, and as having been transmitted by the germ-plasm, which was not subject to the action of various temperatures in the first instance. The reaction forms have an additional claim upon our attention, since they are the ones which distinguish northern and southern races of many animals. The crucial test of the value of the alterations induced in the mice is the one applicable to all of the experimentation on this subject, a test in which two parallel series of cultures, one under the altered environment and the other under usual conditions, should be kept going continuously for a longer series of generations, lots being withdrawn from both, from time to time, for continued comparative culture in normal habitat and under other conditions.

The same considerations apply to Kammerer's experiments with salamanders in which the reproductive habits of *Salamandra atra* and *S. maculosa* were altered to resemble each other by specialized exposure to climatic factors, and while his later work with *Lacerta* has resulted in the production of some extremely striking changes in the color bands which behaved in a Mendelian fashion when paired, yet these have not been followed to the third and fourth generations. The permanency of the induced changes seems highly probable in this case. There is, however, a great body of properly authenticated evidence which demonstrates conclusively that external agencies acting upon bacteria, crustaceans, beetles, fungi and some of the higher types of seed-plants have been seen to result in the appearance of new types or genotypes, which have been found to transmit their characters perfectly through so many generations as to indicate practical permanency.

The names of Beijerinck, Winogradsky, Lepeschkin, Hansen and Barber are associated with records of mutational occurrences in pedigreed strains of yeasts and bacteria under pressure of unusual media or other environic conditions. Some aberrants being propagated by fission and others through the spore stage, some only by selection and others independently. In addition Pringsheim finds many accommodative responses to unusual culture media, temperatures and poisons, which may be cumulated and become fixed in these lower organisms, being transmissible by fission or by spores.

My own earlier work with relation to this subject consisted chiefly of ovarial treatments in which the main and accessory reproductive elements of seed-plants were subjected to the direct action of solutions of various kinds. A new combination of characters constituting a distinct elementary species or genotype was obtained in one plant, and the divergent type has been found to transmit its qualities in the fullest degree, as far as tested, to the fifth generation. Still more marked forms were obtained in a second genus, the divergent progeny being lost in transference to the Desert Laboratory, while distinct responses have been obtained in the extensions of these experiments upon species representing widely different morphological types in Arizona. The greater majority of the tests have been made upon plants growing under natural conditions, so that environmental reaction in addition to that of the specific reagents might be excluded. Progenies representing many species, including thousands of individuals, many of which are divergents, are now under observation. Absolute finality of decision with respect

to the standing of the new types may be reached but slowly.

The important results of Tower, in which new types and various hereditary departures in the Leptinotarsæ were induced by the action of climatic factors on the germplasm, have been so fully described and repeatedly cited that any further description is unnecessary at the present time.

Gager produced chromosomic irregularities by the exposure of ovaries of *Œnothera* to radium emanations a few years ago and some of the progeny from treated parents were aberrant, but the transmissibility of the new characters was not tested. By the use of similar excitations Morgan has recently induced the appearance of white eyes and short wings in the fly, *Drosophila,* which characters seem to be fixed and fully transmissible. Both are sex-limited and Mendelize when paired with red eyes and long wings.

Woltereck's cultures of *Daphnia* have yielded some facts of unusual interest in the present connection. The particular group of this crustacean furnishing the experimental material is taken to be very variable, and it was subjected to over-feeding, with the immediate result that the variability of the form of the head appeared to be widened, the size of this structure being increased. This disappeared when lots from the cultures were restored to normal conditions in the earlier stage of the work. After three or four months of over-feeding, the form of the head came within narrower limits, and fewer aberrants were seen, while lots returned to normal conditions, showed a slower restoration of the original form of the head. Two years after the cultures were begun, it was found that the original head form was not displayed by young restored to normal nutrition conditions, the larger helmet being persistent. It seems fairly certain that a new genotype resulted from the long-continued action of the culture medium, which must have influenced the soma and germ-plasm contemporaneously.

Klebs, who has long been concerned with the morphogenic reactions of plants, has determined a series of conditions under which stages of mycelial development, asexual, zoospore and sexual or oospore formations in filamentous fungi may be inhibited or variously interchanged. Much more important reactions were obtained from *Sempervivum,* the live-forever of the garden. In this plant, dense rosettes or propagative bodies are formed at the ends of some branches, and inflorescences were replaced by single flowers by experimental excitation: the number and arrangement of the floral organs as well as of the stamens and carpels could be altered. Furthermore, the deviations in question were found to be transmissible in guarded seed-reproductions.

Lastly we now have the fortunate experiences of Zederbauer with *Capsella* which has yielded some conclusions of exceptional importance. A genotype of *Capsella bursa pastoris* resembling *taraxacifolium* was found on the lower plains of Asia Minor, and displayed the well-known characters of this form, including broad leaves, whitish flowers, and stems 30–40 cm. high. A highway leads to a plateau at an elevation of 2,000 to 2,400 meters, along which the plant has been carried by man, and in this elevated habitat it has taken on certain alpine characters, including elongated roots, xerophytic leaves, stems 2, 5 cm. high, reddish flowers, with a noticeable increase of the hairiness of the entire plant. That the distributional history has been correctly apprehended seems entirely confirmed by the fact that when seeds are taken from the lowlands the

alpine characters enumerated are displayed at once as a direct somatic response. When seeds are taken from plants on the elevated plateau where their ancestors may have been for many years or many centuries (perhaps as long as 2,000 years) and sowed at Vienna, and at other places, it was found that in four generations the leaves lost their xerophytic forms and structure, but the other characters were retained within the limits of variability. The stems showed an increase in average length of 1 to 2 cm., the roots changed as much, but the reproductive branches and floral organs retained their alpine characters. The slight modifications undergone by these features were seen to reach a maximum and to decrease in the latest generations cultivated. The structural changes and implied functional changes are originally direct somatic responses; there is no escape from the conclusions that the impress of the alpine climate on the soma has been communicated to the germ-plasm in such a manner as to be transmissible, and the suggestion lies near that repeated and continued excitation by climatic factors may have been the essential factor in such fixation.

A related phase of the subject is that of the interposition of environic factors in mutations and hybridizations. De Vries appears to have first called attention to the fact that the composition of hybrid progenies of mutants with each other and with the parental form might be altered by nutritive conditions, and the author has described mutants given off by *Œnothera Lamarckiana* in New York which had never been seen in Amsterdam. Furthermore, in discussing the divergent results of De Vries and myself, obtained by crossing the same forms in Amsterdam and New York, the suggestion was made in 1905, that "the manner in which the various qualities in the two parents are grouped in the progeny might be capable of a wide range of variation. Many indications lead to the suggestion that the dominancy and prevalency, latency and recessivity of any character may be more or less influenced by the conditions attendant upon the hybridization; the operative factors might include individual qualities as well as external conditions."

Much more striking evidence upon the matter has been recently obtained by Tower in intercrossing *Leptinotarsa decemlineata, L. multilineata, L. oblongata* and other species in their habitats in southern Mexico, and at the Desert Laboratory. The observations were carried on with both normal and hybrid crosses, in crosses between races which had been built up selectively, and between forms which arose as sports proving conclusively that external agencies may alter the action of paired reproductive elements. Kammerer's contribution to this subject consisted in demonstrating that newly induced color characters in *Lacerta* displayed dominances different from those of the original types, while Tennent has proved that the dominances in crosses of *Hipponoe* and *Toxopneustes* variously attributed to seasonal changes, variations in temperature, etc., are in reality to be attributed to the concentration of the OH ions in the seawater.

The first realization of results of importance from cultures widely extended geographically have been obtained in the experiments with Leptinotarsæ by Tower, in which various species of these beetles were studied in their habitats in southern Mexico, in open air and glass houses as far north as Chicago, as far east as the Atlantic and as far west as the Desert Laboratory. Facilities for work upon special problems are now being organized at sev-

eral places and many contributions to the subject may be expected within the next decade.

The plan for work upon the problems of special interest in connection with the Department of Botanical Research of the Carnegie Institution of Washington, implies the establishment of experimental cultures in localities which furnish distinct types of climate or which have characteristic congeries of meteoric factors, as indicated by the vegetation indigenous to them. Secondly, these localities have been chosen with regard to their geographical relations so far as possible, in order that the possible and probable fate of migrating species might be studied. The behavior of plants in these localities is recorded as to anatomical alteration and physiological departure. Having detected some such feature of apparent importance, its reappearance in plants from seeds carried to the original habitat and other locations is followed as one line of evaluation. Contemporaneously, the form is taken into the laboratory and here by analytical experimental tests the effort is made to ascertain to what special agencies the departures are due. Such determination of the identity of exciting agencies has been made by Stockard, who found that the cyclopean embryos of *Fundulus* occurring in nature could be induced by the action of magnesium salts introduced into the sea-water containing the eggs.

Our increased insight into the nature of natural groups of organisms has shown the necessity and suggested the means of observing certain distinctions and precautions in this work. Thus it is of the greatest importance that the living material shall be shown to be either simple genotypes or that its phænotypic nature be apprehended in order that the integration and combination of these forms shall not be mistaken for environic effects. When a lot of plants is taken from one plantation to another, data of the original locality are preserved, as the stand of the plant in that place serves as the control. If the plant is multiplied vegetatively in the test, it might reveal a possible complex character of the material in bud sports, but other divergencies might be well ascribed to local effects. On the other hand, if introduced in the form of seeds, the possible complex character of the material would soon become apparent, especially if the generations were followed properly. In the actual management of the cultures, it is found profitable to reintroduce forms from the original or control lot of various species in order to follow the first stages of their adjustment repeatedly.

The genetic character of environic effects remains to be considered. In any species or genotype there is, withal, a limited number of things included within the morphological possibilities. The appearance of any character in an acclimatization culture raises a question at once as to the standing of the new feature. Is it a regressive character, once displayed by the species and now recalled, or is it to be considered as a character *de novo,* arising simply and directly in response to the external agencies which have been seen to induce it? Thus our general knowledge of the Cactaceæ leads us to assert with some confidence that the reappearance of a full complement of spines in a prickly pear, from which they had all but disappeared, is a regression or return to the condition of the greater majority of the group, a condition which must have been shared by its ancestors at no remote stage in its progressive development.

None of the attempts hitherto made to perfect a theoretical conception which would be useful in interpreting the mech-

anism of environic responses has had anything more than the most limited usefulness. The stimuli of climatic and many other agencies do not imply the introduction of any strange or new substances into the bodies of the organs affected. These agencies might change the dissociations in such manner as to modify the relative number of free ions and thus alter the molecular complex of the living matter in a very important manner however. The intricate play of enzymatic action might also be altered, and any modification of the relative reaction velocities of the more important processes might result in material and permanent change, especially in those cases, in which external agencies interfere directly with the action of the germ-plasm.

The introduction of solutions into ovaries or the exposure of reproductive elements to unusual irradiation may raise the additional liability of disturbed polarity and of modified surface tensions in the cells. It is conceivable that the rearrangement or disturbance of the localizations of substances, especially the mineral salts, might seriously modify the capacities of the bearers of heredity. These direct and material possibilities offer an adequate basis for the organization of experimental research upon the main subject as well as the means of interpretation of results without recourse to schemes of particulate inheritance or theories as to the constitution of germ-plasm to which may be ascribed usefulness in the discussion of other problems in evolution.

The theoretical considerations which might lead us to assign all cases of perpetuation of environic effects to the direct action of the exciting agency upon the germ-plasm are perfectly competent to be questioned with each new bit of evidence brought forward. My own results so far have been all of this kind, as are many of the instances cited, but the case does not appear so simple when, as in *Sempervivum,* somatic alterations are induced late in the ontogeny and are transmitted by seeds borne on the altered branches, and equally serious doubts are raised when one considers the multifold somatic alterations of *Capsella* and the fact that they must be repeated dozens, perhaps hundreds, of times before being transmissible. One must not lose sight of the fact that the soma is itself the most closely interlocking environment of the germ-plasm, and not until the germ-plasm has been exposed to interaction with a changed soma for repeated generations does it undergo the changes necessary to an altered heredity.

The problems of real interest, however, are those which concern the actual influence of environment upon evolutionary development, and with regard to these many generalizations of importance are becoming possible, and their brief summarization may suggest some encouraging advances.

First it is to be seen that not all environic effects induced in the laboratory or by transplantations are heritable, although they may be carried over for two or three generations. No satisfactory basis has yet been found upon which it might be predicted that any effect would be ephemeral or permanent. The characters induced in an hereditary line may be regressive, or awakened latencies or organizations *de novo.* The alterations which become permanent may be cumulative in construction, although they are mutative or abrupt in their appearance in most instances. Abruptly displayed by some organisms, yet they may not become heritable until the germ-plasm has been repeatedly subjected to the direct action of the exciting agency or to the effect of a changed soma for many generations.

Orthogenetic or heterogenetic as to direc-

tion, they may be consequently accommodative or correlational, incidentally adaptive, or wholly inutile in their functional relations. D. T. MACDOUGAL

EDUCATIONAL AND INDUSTRIAL EFFICIENCY

THE latest bulletin of the Carnegie Foundation has many attractive features. The report has evidently been made up in a spirit of good will to education, and any sting that it may contain should be removed by the admirable introduction by Dr. Pritchett. In the course of more than a hundred and thirty large pages the author, Mr. Cooke, makes a number of excellent suggestions, which are none the less excellent because of their lack of novelty. He is aware that the charge of Philistinism might easily be suggested by the tenor of his remarks and he makes some effort to protect himself accordingly. His peculiar point of view seems to give undue prominence to "the cost per student hour," but although we hear much of this phrase in the report we are distinctly told in one place that "It should be borne in mind that the cost per student-hour has absolutely no value in distinguishing relative educational values." If this had been placed as a headline to all the pages, it would have greatly improved the value of the report, and would have been in harmony with this other admirable sentence which might with equal propriety have been inserted as a foot-note to every page: "In the last analysis the usefulness of a university is the measure of its mental, moral and spiritual product—and product interpreted as broadly as you please."

However, although there is much that is excellent in the report, it has many weaknesses. It is written from the point of view of the man who is used to report on the efficiency of a glue factory or soap works. Whenever it touches the strictly educational field and gets away from the factory the trail of the amateur is over it all. It is full of commonplaces, and there is scarcely a question raised that has not been discussed *ad nauseam* by college professors and other officers. It is not lacking in confidence. One marvels at the temerity even of an "efficiency engineer" who can lay down the law so definitely as to how to teach physics, how to conduct a recitation, how to carry on research, when most of us who have devoted our whole lives to such problems are far less confident. There are, however, here and there some pleasing evidences of diffidence. In discussing the important educational problem of janitor service Mr. Cooke says, "A sharp line should be drawn, *probably,* between the cleaning of the buildings and the care of apparatus." The use of the word "probably" is a master-stroke. It conjures up pleasing pictures of janitors handling the delicate instruments of a physical laboratory just as they furbish the brass plates of a glue factory—if indeed "the snap and vigor of the business administrator" which Mr. Cooke admires so much decree that such things are a necessary adjunct to the dignity of the factory. Almost on a par with this use of "probably" is the statement that "There is a good deal of the feeling that lectures to be good must in a way bear the marks of the inspiration of the moment. But a good many men who have the reputation of being high authorities assured me that the carefully thought out plan for a series of lectures would win out every time over the inspiration of the moment idea." Of course they assured Mr. Cooke of this, but they must have smiled at the naïveté of the question and wondered who ever suggested that the presentation of a scientific subject be left "to the inspiration of the moment."

The report shows many evidences of ignorance of the history of education. It suggests as novelties plans that have been tried for centuries and abandoned only after careful consideration. Such, for example, is the suggestion that the rules for the conduct of the students and the punishments for their breach should be put into precise form. The collection of such rules from the archives of the older universities would fill many volumes. Again he says, "It may turn out that ultimately the matter of examinations will be handled by an agency outside of the depart-

ment." This, to his vision, is a far-off divine event to which the whole educational creation is moving. If so, it is moving backwards.

Mr. Cooke's remarks on the economic use of rooms and buildings are, for the most part, eminently sensible, although he contributes nothing new to the discussion of a very old problem. His economic sense is shocked on learning that a lecture room in the department of physics is used only four hours a day, just as it must be shocked when a church is used only a few hours a week, or a life belt only when it is actually needed. In some of his criticisms under this heading he seems to forget that colleges have to make the best of the materials that are available and that in many cases an apparently uneconomic use of rooms is forced upon them because their buildings are old, or were designed for other purposes than those to which they have now to be put. He commends one institution for a space-saving device and wonders that it is not adopted in all departments, the fact being that the newer buildings were designed for its use, but the older ones were so constructed that its adoption there would not have been a real economy.

Mr. Cooke displays unusual weakness when he takes up the subject of research. Indeed most of what he says on this subject must be received with that mixture of astonishment and embarrassment with which we listen to the words of a distinguished friend who pronounces an absurd judgment on an important subject that he has evidently not mastered. Listen to this. "I believe there is a distinct disadvantage to undergraduate students to be near research work. I think in the case of physics research workers, their good *influence is more often offset by the introduction into the undergraduate laboratories of the necessarily deliberate and experimental methods of the research laboratory"!!* How unfortunate if "deliberation" and the "experimental method" should contaminate the laboratories —it might detract from the "snap and vigor" of these promising undergraduates. And yet one wonders what possible use there can be in teaching physics at all, if so much care is to be taken to guard the students from catching its spirit and grasping its method. We, in our ignorance, had imagined that the method and the spirit of science were its very essence, especially where undergraduate learning is concerned. We should have accounted any system of education that failed to recognize this as but so much dross and dung (if, at this season, a Scriptural phrase may be permitted) even if it resulted in every undergraduate gaining 100 per cent. in the examinations conducted by Mr. Cooke's "bureau of inspection."

Perhaps enough has been said to indicate that there are serious blemishes in this bulletin. If, however, it be taken for just what it is worth, it can do no harm and may do much good. We should regard as a friend every one who helps us to improve our methods and if this report enables us to keep our accounts better, or make a more economical use of our machinery, of course it will be heartily welcomed. The most serious objection that I see to it lies in its abuse rather than its legitimate use. I fear that it will tend to increase the administrative machinery of our educational institutions, machinery that is already far too much in evidence. When one listens to all the criticism of our colleges and thinks of the great things that have been accomplished elsewhere with so little machinery and so little noise, one wonders whether it might not be better for us also to settle down to quiet work. Then I confess that all this talk of "cost per student hour" strains my patience to the limit, especially when it is presented under the heading "gauge of efficiency." Mr. Cooke frankly recognizes its usefulness to this end, but others may be led astray by the specious analogy with the workings of a factory. A college that had reached the acme of perfection as gauged by Mr. Cooke's standards might be highly inefficient as an instrument of real education. Mr. Cooke tells us that in studying the colleges he has constantly held in mind "the equivalent mechanism" used in the industrial world and apparently he looks forward with pious expectation to the day

when our colleges will run with the uniformity of looms in a mill. Granting with Mr. Cooke that there is much that the administrators may learn from the mill manager, it is to be hoped that enlightened public opinion will never permit us to forget that in all matters that are really vital to education there is no "equivalent mechanism" in the industrial world. We are not making shoes or bricks or cloth, but are dealing with material of the utmost complexity and variety, with no two specimens quite the same and no two that need just the same treatment. Uniformity in the product is not only unattainable, it is not even desirable, and factory methods are entirely out of place. If we neglect the human factors in our education we are lost and we can not overlook the fact that, without such bulletins as this, there are already plenty of forces at work to give sufficient prominence to mechanical conceptions and mechanical tests. Nor does it require any special effort in this country to stimulate admiration for the "snap and vigor of the business administrator," while the value of snap in the domain of education may very easily be overestimated. Especially am I fearful of its effect on the teacher and the investigator. His path is not too smooth already and even now there are many forces drawing him from the educational sphere where best he can serve society. Think for a moment of the effect on men like Newton or Faraday of the "snap and vigor" treatment that Mr. Cooke suggests in his discussion of research. They must make frequent reports on the progress of their research and constantly justify the expenditure thereon. The superintendent of buildings and grounds, or other competent authority, calls upon Mr. Newton.

Supt. Your theory of gravitation is hanging fire unduly. The director insists on a finished report, filed in his office by 9 A.M. Monday next; summarized on one page; type-written, and the main points underlined. Also a careful estimate of the cost of the research per student-hour.

Newton. But there is one difficulty that has been puzzling me for fourteen years, and I am not quite . . .

Supt. (with snap and vigor). Guess you had better overcome that difficulty by Monday morning or quit.

R. C. MACLAURIN
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
December 24, 1910

SCIENTIFIC NOTES AND NEWS

AT the recent annual meeting of the American Anthropological Association, held in Providence, R. I., officers were elected as follows: *President,* Dr. J. Walter Fewkes, Washington, D. C.; *Secretary,* Dr. George Grant MacCurdy, New Haven, Conn.; *Treasurer,* Mr. B. T. B. Hyde, New York, and *Editor,* Dr. John R. Swanton, Washington, D. C.

THE following officers of the American Fern Society were recently elected for 1911: *President,* Dr. Philip Dowell, Port Richmond, N. Y.; *Vice-president,* Miss Nellie Mirick, Oneida, N. Y.; *Treasurer,* Mr. Harold G. Rugg, Hanover, N. H.; *Secretary,* Mr. L. S. Hopkins, M.A., Pittsburgh, Pa.

ON December 20 the Paris Académie de médecine held its annual election, Professor Lannelongue, the vice-president, assuming the presidency and Dr. Gariel, professor of medical physiology at the Paris Medical School, being elected vice-president.

LORD AVEBURY has been elected a corresponding member of the Paris Academy of Sciences, in the section of anatomy and zoology.

THE section of chemistry of the Royal Academy of Science of Stockholm has elected Mme. Curie a foreign member in place of the late Professor Cannizzaro.

MR. ERNST LEITZ has received from the University of Marburg the honorary degree of doctor of philosophy on account of his services to science in having constructed for over fifty years instruments of scientific value.

A 450-acre forest reserve in Vermont has been named the "L. R. Jones State Forest" in recognition of the services of Lewis R. Jones, for twenty years associated with the

University of Vermont as professor of botany, and now professor of plant pathology in the University of Wisconsin.

Professor C. V. Piper, of the U. S. Department of Agriculture, sailed from San Francisco on January 7 for Manila. He goes to the Philippine Islands primarily to investigate the possibilities of growing hay there suitable for horse feed. Before his return he will make extensive investigations of forage crops in India.

Professor Charles I. Corp, assistant professor of mechanical engineering at the University of Kansas, has gone to the University of Wisconsin to do a year's research work in the hydraulic laboratory.

Under the auspices of the Harrison foundation, Dr. Arthur Gordon Webster, professor of physics in Clark University, will deliver at the University of Pennsylvania a series of lectures on "Sound in Speech and Music: Its Production, Reproduction, Transmission and Measurement."

Professor Charles E. Monroe, of George Washington University, read before the American Philosophical Society, on January 6, a paper on "The Investigation of Explosives at the Pittsburgh Testing Station."

A stated meeting of the Geographic Society of Chicago was held on January 13, when a lecture was given by Professor Charles K. Leith, of the University of Wisconsin, on the subject "A Summer on Hudson Bay." A reception followed the lecture.

Dr. Francis Gano Benedict, director of the Nutrition Laboratory of the Carnegie Institution, formerly professor of chemistry at Wesleyan University, gave an illustrated lecture on "The Influence of Mental and Muscular Work on Nutritive Processes" before the Middletown Scientific Association on January 10.

On the evening of January 9, at the Brooklyn Institute of Arts and Sciences, Dr. Edwin F. Northrup, of Princeton University, delivered a lecture entitled, "New Devices for Electrical Measurements." The lecture was illustrated with lantern slides and a collection of instruments for precision measurements in electricity.

At the fifth annual meeting of the American Society of Biological Chemists held in New Haven, Conn., December 28–30, 1910, the following resolutions were adopted by the society concerning the recent death of Dr. Christian A. Herter, one of its charter members:

Resolved, that in the recent death of Dr. Christian A. Herter, the members of the American Society of Biological Chemists, assembled at New Haven for the annual meeting of the society, desire to express their sorrow at the loss of an eminent colleague and their appreciation of the services rendered by him to the science which the society represents. By his own work, by the inspiration, encouragement and support which he so freely gave to others, he rendered inestimable service to the advancement of biological chemistry, and especially in its relation to the problems of practical medicine. His kindness of heart and his sympathetic interest in the work of his associates, coupled with modesty regarding his own achievements endeared him to all who came in personal contact with him. The spirit which animated his life and which guided his actions in the direction of service to others is expressed in material foundations which he has left for acquiring and diffusing knowledge. The same spirit is expressed in the influence he has exerted on the lives of his associates.

Resolved, that as a tribute to the memory of our late associate, these resolutions be inscribed on the permanent records of the society and a copy sent to his bereaved family.

(Signed) Russell H. Chittenden
John J. Abel
A. N. Richards
Committee

The American Breeders' Association will meet at Columbus, Ohio, from February 1 to 3, under the presidency of secretary James Wilson.

We learn from the London *Times* that the new "Institut de Paléontologie Humaine," which Prince Albert of Monaco has promised to found in Paris, is to be placed under the patronage of the state. It will be administered by a council of six members, who are to

be of French nationality, and who will be assisted by a committee of French and foreign authorities. The new foundation will be installed in a building of its own which is to be erected in Paris, and in addition to a capital of over $300,000 the institute will be presented with the Monaco collections.

THE five academies of the French Institute held their quarterly plenary sitting on January 5, when the meeting discussed the question of the eligibility of women candidates for the institute. The motion in favor of the admission of women, which was prompted by the candidature of Mme. Curie for one of the vacant seats in the Academy of Sciences, was rejected by 90 votes to 52. A resolution was adopted in which it was declared that, although the institute did not pretend to dictate to the separate academies, there was an "immutable tradition" against the election of women, which it seemed eminently wise to respect.

THERE has been presented to the American Museum of Natural History and placed on exhibition in the Morgan-Tiffany Gem Room a specimen of the new gem Morganite (rose beryl). It is a long oval stone of rich rose color and weighs 57¼ carats. This gem was named by Dr. George F. Kunz, the honorary curator of gems of the American Museum, at a meeting of the New York Academy of Sciences on December 3, 1910.

ACCORDING to the London *Times* the German Antarctic expedition, under the command of the Bavarian explorer, Lieutenant Filchner, will leave Germany early this year for Buenos Aires, and will proceed from there at the beginning of October *via* South Georgia and the Sandwich Islands to the Weddell Sea. The route has been chosen so as to allow of oceanographical research on the way. On arrival in the Weddell Sea it is proposed to establish a base station on the eastern coast as far south as possible, with the necessary equipment for a year's research. A party of ten men will be landed, of whom six—a geologist, a meteorologist, an astronomer, a doctor who is also a biologist, a cook and a sailor —will stay in the station, while the remaining four will undertake a long sledge expedition into the interior of the South Polar continent. Meanwhile the ship will return to the Atlantic Ocean to carry out coastal observations and oceanographical work.

A LETTER from Professor Frost received at the Harvard College Observatory states that Nova Lacertæ was observed at the Yerkes Observatory on December 31, 1910, and January 2 and 3, 1911. An excellent photograph of the spectrum was obtained by Frost with the 40-inch telescope which showed that the spectrum closely resembled that of Nova Aurigæ and Nova Persei, No. 2. The position of the Nova for 1911.0 was determined by Professor Barnard as follows: R. A. $22^h\ 32^m\ 11^s.79$; Dec. $+52°\ 15'\ 19''.8$. A star in the exact position of the Nova, of about magnitude 14.0, was found on plates made on August 7, 1907, August 22, 1909, and August 24, 1909. From a photograph made with the 24-inch reflector, Parkhurst and Slocum suspect nebulosity about the Nova, and find the photographic magnitude on January 2 and 3 to be 7.12 and 7.21. Professor Campbell writes that very satisfactory observations of the Nova were obtained at the Lick Observatory on December 31 and January 1 and 2.

THE Berlin correspondent of the *Journal* of the American Medical Association writes that on December 10 a mausoleum for Robert Koch was opened in the institute for infectious diseases of which he was director for many years. It was formed from some rooms of the institute. The funds for the rebuilding, amounting to about $5,000, were contributed by his many pupils and friends. The mausoleum consists of two rooms, the first a small antechamber in which some of the scientific instruments used by Koch, his numerous domestic and foreign honorary diplomas, models of the medals awarded to him and other memorials of his life are placed. Here also is the so-called "golden book" of the Robert Koch Foundation for the War on Tuberculosis that contains in an artistic setting the history of the foundation and the autographs of the larger contributors to the fund. In the

special memorial hall, in a niche that is closed with a white marble slab, is placed the urn that contains the ashes of Robert Koch. The walls and floors are all of marble. Over the niche for the urn is a marble tablet on which is a portrait of Koch in relief, larger than life size, and on the opposite wall the chief dates of Koch's life are engraved. On December 11 the special memorial service took place in the new hall of the university. The large hall which seats about 1,500 persons was filled with a mourning throng which included many physicians, especially members of the Berlin medical faculty, representatives of the government and the chief German medical faculties and representatives of many medical societies as well as of foreign universities and societies. The memorial address was delivered by Professor Gaffky, who was for many years a pupil of Koch and is his successor as director of the institute for infectious diseases.

UNIVERSITY AND EDUCATIONAL NEWS

The report of the tax appraiser on the Kennedy estate has now been published, showing that the bequests for educational and public purposes are even larger than had been anticipated. Columbia University receives $2,358,000, New York University $952,000 and Robert College, Constantinople, $1,800,000; the bequests to the New York Public Library and the Metropolitan Museum of Art are in the neighborhood of $2,800,000. Barnard College and Teachers College, Columbia University, each receive $100,000, as do Hamilton College, Elmira College, Amherst College, Williams College, Bowdoin College, Yale University, Tuskegee Institute and the Hampton Institute. Lafayette College, Oberlin College, Wellesley College, Berea College and Anatolia (Turkey) each receive $50,000. The bequest to hospitals and to the boards of the Presbyterian Church are very large.

Mr. Carnegie's latest gift of $3,800,000 to the Technical Institute in Pittsburgh is to be used approximately as follows: $2,300,000 for increase of present endowment, $1,375,000 for new buildings, $100,000 for additional equipment and $25,000 on grounds.

The residue of his estate, valued formally at "not more than $50,000," is divided between Yale and the University of Leipzig by the will of Dr. Albert Seesel, a New York physician. With the income there is to be founded at each institution the "Theresa Seesel Fund" in memory of his mother, to be used for researches in biology.

A lectureship on the history and institutions of the United States has been established at Oxford, to be held by American scholars. The subject matter of the lectureship is to be the political, institutional, economic or social history or conditions of the United States.

The trustees of the University College of Medicine, Richmond, Va., have awarded contracts for a new college building, to cost $135,000, to replace the one recently burned.

The University of Cincinnati sent as delegates to the meeting of the Ohio College Association and the Ohio Association of Medical Teachers at Columbus during the Christmas vacation, President Dabney, Dean Woolley, of the Medical School, and Professor Jones. President Dabney presented a resolution which was unanimously adopted, asking the Board of Medical Examiners of Ohio and the Ohio Medical Association to join with the Ohio College Association in memorializing the legislature to advance the standard for entrance to the medical colleges in Ohio, by requiring that the entering student shall have done two years of college work, including in this work chemistry, physics, biology (each of these with laboratory courses) and modern languages. The Medical College of the University of Cincinnati has already adopted this standard.

Dr. W. H. Howell has resigned as dean of the Johns Hopkins Medical School, and has been succeeded by Dr. J. Whitridge Williams.

Dr. Josiah H. Penniman, professor of English and formerly dean of the college department of the University of Pennsylvania, has been chosen vice provost.

Dr. David L. Edsall, professor of medicine in the University of Pennsylvania, has

accepted a professorship of preventive medicine in Washington University, St. Louis.

PROFESSOR GUIGNARD, for fifteen years director of the Paris School of Pharmacy, has resigned his appointment and is succeeded by M. Henry Gautier, professor of mineral chemistry at the school.

DISCUSSION AND CORRESPONDENCE

SPECIAL COMMITTEES ON ZOOLOGICAL NOMENCLATURE

TO THE EDITOR OF SCIENCE: The International Commission on Zoological Nomenclature is trying a plan of cooperation with international committees representing the various branches of zoology in an effort to determine in how far it will be possible to reach a unanimous agreement upon the names of the most important zoological genera, together with the type species of the genera in question.

The International Commission of Medical Zoology, established at the Graz Congress, has undertaken a study of over three hundred names applied to the trematodes reported as parasitic in man. This commission is to pass upon the zoological status of the names in respect to synonymy and validity. The report will then be submitted to the International Commission on Nomenclature. It is the plan of the latter commission to publish the report, and to invite criticisms upon the same from the zoologists of the world. After ample opportunity is given for such criticism it is the plan of the commission on nomenclature to attempt to reach a unanimous ruling upon the names, and to submit this ruling to the next international congress.

The secretary of the international commission on nomenclature is inviting specialists in other groups to conduct similar studies upon the most prominent and best known genera. The plan adopted is for the secretary to select three or more specialists of unquestioned international reputation in a given group, and to request these workers to add to their committee any colleagues whom they may desire. It is hoped that by this means preliminary studies of fundamental and permanent value may be conducted, and that the contending factions, in respect to nomenclature, may be harmoniously united.

The secretary of the commission on nomenclature is adopting the plan of taking man as a center, first working out, so far as may be done unanimously, names to be adopted for the animals most intimately associated with man, and while the undertaking may require years of patient labor, it is hoped eventually to establish a list of not less than ten thousand generic names, agreed upon unanimously, first by the special committee, and then passed upon unanimously by the commission on nomenclature. It is hoped, further, that by this plan an immense number of useless synonyms can be unanimously agreed upon as such, and gradually eliminated from general zoological literature.

The scheme naturally depends upon the amount of cooperation on the part of the special committees, which will be formed as rapidly as the work will justify.

C. W. STILES,
Secretary International Commission on Zoological Nomenclature

FACTS AND PRINCIPLES

TO THE EDITOR OF SCIENCE: May I have space in your columns to reply to the criticism of Professor R. S. Woodworth in your issue of November 25, on my article, "American Educational Defects," which was printed in SCIENCE on October 28, 1910? I have no desire to enter into any needless controversy, but Professor Woodworth seems to me to have misunderstood my language and misconceived my purpose in a way that makes an answer desirable.

There would be little profit in my discussing with Professor Woodworth whether my article is banal or not, which is purely a matter of taste and judgment; but one observation in this connection seems to me pertinent, namely, that there is nothing particularly novel about truth, and that, if educational inefficiency is as prevalent as I have claimed it to be, it would not be strange if it had

been noted repeatedly, nor that there should be general agreement as to its main cause. I should also like to add the explanation that I did not aim to present novel so much as significant truth, and that in writing I bore in mind the maxim of Dr. Johnson to the effect that men need to be reminded rather than informed.

It would also be idle to discuss the orthodoxy of my method. "Orthodoxy," a witty English bishop once explained, "is my doxy; heterodoxy is another man's doxy," and the same definition will serve for what is sound scientific method to-day. I did not aim at orthodoxy of method, but at effective presentation of truth in writing; and it seems to me that this is more important than orthodox procedure. In my discussion I had to treat a very large subject within very narrow limits, and there is less detail in it than I should wish, but the practical result of my method was to enumerate certain abuses and limitations that I thought I detected in our educational theories and practises, and to explain them as the result of certain economic and temporal conditions the existence of which I indicated. Now whatever the theoretical excellence and unquestioned orthodoxy of Professor Woodworth's method, its practical result in his criticism, if he wished to counteract the effect of what I said. should have been to bring forward some reason for believing that the abuses and limitations that I have pointed out do not exist, and that I am either mistaken or malicious when I say that they do. Instead of this, however, its practical result is to use a great many indefinite expressions as if they had an exact significance, and to claim that my case fails unless college presidents and members of governing boards profit directly from the way they administer their trust.

The question of the consistent and accurate use of language is, I know, quite as indeterminate as the two preceding points I have dealt with; for experience has taught me how the mobile and fluid nature of philosophic ideas prevents their being designated and differentiated with entire success by means of language. In an article as compressed as mine, I had to use far fewer checks and elaborations than the character of the ideas demanded, but in spite of this, I do not feel that Professor Woodworth has demonstrated that I have been guilty of any loose or inconsistent use of language. I used the word commerce, I think, consistently as "a gigantic business," founded as much on the caprices as on the necessities of men, an activity which is therefore likely to become dominated by "a pursuit of gain" that is more apparent than real which, instead of being an aid to progress, becomes a corrupting influence by creating an indifference to or an unconsciousness of much good that is equally important but less tangible. I did not mean to deny the value of commerce, and I did mean to make clear my opinion that, as a guide for human activity, it is an improvement over anything that has directed society in its earlier stages. My purpose was simply to show that the absolute control of thought and aspiration by any one activity is bound to create weaknesses that it is the business of education to strive to correct. In using the word commerce in the sense I have given, I have used it in accordance with a definition at once more specific and more comprehensive than Professor Woodworth's definitive one; and I have also, I think, laid more emphasis on its vital principle than on its visible exterior, which seems to me a sufficient explanation of what my meaning is when I say (as he predicted I would) that his criticism is an illustration of a very marked tendency to deal with facts and to neglect principles.

Sidney Gunn

Massachusetts Institute of Technology,
December 2, 1910

SCIENTIFIC BOOKS

The Conservation of Natural Resources in the United States. By Charles Richard Van Hise. 8 × 5½ in., pp. xiv + 413, 16 plates. New York, The Macmillan Company. $2.00 net.

As an expert in ores, an authority on geol-

ogy, a leader in education, and a broad student of public affairs, President Van Hise is perhaps better equipped than any one else to treat the natural resources of the country, both in detail and in their relation to the general welfare; and the excellence of his equipment is attested by the completeness and timeliness of his treatise. Conservation of late has become a cult, the influence whereof extends to every section of the country and pervades a large part of our population; yet there is a dearth of data within public reach, partly by reason of the unfortunately limited edition of that three-volume report of the National Conservation Commission containing the fullest inventory ever made of the resources of a nation—and Van Hise's compact book is designed to meet the current condition.

Beginning with a summary history of the conservation movement, the natural sources of national existence are treated in order as mineral resources, water, forests and land, with a general discussion of conservation and mankind. Of the mineral resources the fuels—coal, peat, petroleum and natural gas—are quite properly placed first. Next to America's contribution of a form of government, the most striking fact in the development of the United States is the exploitation of the mineral fuels. This has been done with extraordinary rapidity—virtually within three quarters of a century, chiefly within a generation. The use of mineral fuels not merely made America a manufacturing nation; it multiplied human power over lower nature, and intensified intelligence to a degree revolutionizing the thought of the world. At first idly deemed unlimited in the slack thinking of the time, the use of the abounding natural energy afforded by such fuels so stimulated both industrial and mental growth that new methods arose, especially that quantitative method which forms perhaps the highest expression of human advancement—and as the quantitative method naturally extended to the coals both their limits and the wastes of earlier exploitation were realized and finally measured. The United States contains 60 or 70 per cent. of the coal of the world, and is more richly endowed with petroleum and natural gas than any other country; yet the wastes were long greater than the uses, and even yet combustion is so imperfect that only a small fraction (probably less than 10 per cent.) of the thermal energy of the coal is actually utilized. But new standards are arising with the spread of the conservation movement; heedless waste is reprobated and is rapidly diminishing; while incomplete utilization is receiving attention, and engineers and inventors are devising means for more complete combustion of the coal and larger application of its energy to the development of power. Paradoxically enough, it would appear that the age of steam opened through the mineral fuels will be closed through better use of the same sources of energy; for coal gasified and used in gas engines averages twice the efficiency of the same coal burned under the steam boiler. America's coal underlies an area of some 500,000 square miles, or 13 per cent. of the country, and is estimated to amount to three trillion tons; of late it is mined at the rate of about 450,000,000 tons annually, or say 5 tons per capita for our people; at the current rate of use it would last several thousand years, while at the currently increasing rate (doubling once in seven or eight years) it would be exhausted within 150 years.

Next to coal it was iron that made this country industrially great; the high-grade ores have for a half-century been taken out of the ground and converted into finished product at a rate marking an epoch in world history. When the nation was founded a few pounds of iron sufficed for the average family; now the production exceeds 25,000,000 tons each year, or nearly 700 pounds for each man, woman and child of our entire population. Of high-grade ores we have less than 5,000,000 tons; at the currently increasing rate of mining it would not outlast the middle of the present century—though with proper economy and progressive recourse to low-grade ores the life of the supply will be prolonged at relatively increasing cost.

In no direction is the quantitative method of dealing with resources more novel and helpful than in connection with water—at once a mineral and the menstruum of vitality; and Van Hise applies the method effectively. The average rainfall of the United States is about 30 inches, or only half that required for full productivity of the soil; the aggregate volume is 215,000,000,000,000 cubic feet; or, expressed in terms already familiar throughout the semi-arid region, about 5,000,000,000 acre-feet annually—equivalent to ten Mississippi rivers flowing constantly. Of the total, about one third runs down to the sea in rivers of which many are navigable though little used in aid of commerce—for with the habitual extravagance of the world's wildest wasters our people prefer to pay three or four times the cost of water transportation for carriage of their abounding freight by rail. This is the run-off; and the remaining two thirds (forming the fly-off and the cut-off) are considered with respect to both uses and wastes. Not only are the leading facts well brought out, but the equities arising in connection with this resource are discussed with clearness and conviction. It is growing evident—indeed, it is already recognized by many influential citizens—that in the last analysis the waters of the country belong to the people of the country, and must be administered in their interest; and Van Hise cites and discusses the laws and decisions taking this trend.

Our once abounding but now sadly depleted forests are treated along the lines established by the work of the forest service, *i. e.*, at once as sources of timber, preservers of streams and enhancers of the beauty and habitability of the country as a home for a prosperous and patriotic people; and the extent, uses and wastes of the forest resources are listed and discussed in informing fashion. The lands are treated largely with reference to production—a production measured partly by the soil but yet more largely by the water applied to it naturally or through irrigation. Before the exploitation of the mineral resources and timber began, America was the home of a freehold landed citizenry, and the abounding products of the soil not only easily sustained the food-producing population of the time, but left a large margin for export; but now that a large part of our people are engaged in manufacturing and ancillary industries rather than in producing staples for food and clothing, our exports of these staples are declining—and even at home the pinch of reduced production is felt in advancing prices. It is clearly a need of the time to augment the yield of staples, not merely per acre cultivated, but per worker in the field; it is not only needful to make two ears of grain grow where one grew before, but the farmer must double or triple the product of his own work in order that his manufacturing fellows may be fed; and this may be attained by judicious conservation of the energy residing in fertile soil and intelligent husbandry. For even the teeming population of to-day is not the end for this country; our inhabitants and industrial differentiation are increasing with each generation, and must continue to increase apace if this nation is to fulfill its manifest destiny as the chief home and strength of the Caucasian race. Consistently, Van Hise urges conservation and increase of the elements of fertility in the soil; he indicates and deplores the wastes due to soil erosion and negligent farming; and he applies his own expert knowledge in describing the phosphate deposits of the country and advocating their retention and use. In his closing division he especially emphasizes the current movement as one connected with the public welfare and brings out its patriotic character—for in very fact the perpetuity of this most exuberant and wasteful of nations is at stake.

Throughout, Van Hise crystallizes conservation as a definite and trenchant idea, a specific principle, a basis and guide for action: "Do the principles of conservation demand that it [legislation] shall be done?" (p. 97); "Conservation requires us to encourage concentration and coupling in order that we may get the greatest efficiency of the water" (p. 135); "Conservation does not demand that no tree be cut, but that whenever a

tree is cut, measures shall be enforced which will produce another tree" (p. 262)—these are typical expressions.

The book is an outgrowth of a series of twenty lectures, and the arrangement and style reflect the original presentation; there are occasional discontinuities and other minor imperfections which systematic construction in the study would have obviated. In view of that trenchant application of the quantitative method which the conservation movement expresses, it is unfortunate that the indefiniteness of thought and cloak for sharp practise involved in the "long ton" should find expression, still less the rhetorical monstrosity, "short ton"; as if there were in well-chosen American terminology any "short" ton—save that delivered by a dishonest dealer. A misleading expression is "reserves," applied to natural supplies—a term unhappily introduced in this country by a foreign student and carelessly adopted through mimetic instinct; there is indeed a "gold reserve," and there have been "forest reserves," but there are unfortunately no coal reserves or iron reserves in the United States—and the very use of the term tends to confuse thought and thereby retard desirable action.

On the whole, despite the few minor blemishes sure to disappear in later editions, Van Hise's book is a highly useful summary of the facts and statement of the principles involved in the conservation movement; and its issue would seem to meet an urgent need.

W J M.

Theoretical Principles of the Methods of Analytical Chemistry Based upon Chemical Reactions. By M. G. CHESNEAU. Authorized translation by AZARIAH THOMAS LINCOLN, Ph.D. and DAVID HOBART CARNAHAN, Ph.D. New York, the Macmillan Company. 1910. Pp. x + 184. $1.75 net.

The book attempts to show that the phenomena and methods of analytical chemistry can be established on a theoretical basis of thermochemical data and thermodynamic principle, without the use of the electrolytic dissociation theory. In other words, it represents a systematic attempt at practical application of the views held by opponents of the dissociation theory, notably by Professor Kahlenberg.

It is divided into seven chapters. The first examines "the influence of the physical state of precipitates upon their purification by washing (size of grains, crystalline state, colloidal state)." The second chapter deals with the principal types of irreversible reactions used in analysis and with the theoretical principles involved. The third chapter deals with reversible reactions from the thermodynamic standpoint, carefully avoiding the use of the electrolytic dissociation theory: ionic concentrations are absent from the mass law equations, the molar concentrations being raised to empirical fractional powers (Van't Hoff's coefficient i). The fourth chapter introduces the theory of solutions and includes a brief statement of the principal facts upon which the dissociation theory rests. The fifth chapter is devoted to an attempt to show that the dissociation theory can no longer be maintained in science and that it is decidedly overthrown by the work of Kahlenberg. The sixth chapter deals with analytical processes based upon double decomposition of salts. Here for the first time the principle of constancy of the solubility product is stated, then an attempt is made to show that it can be dispensed with, not only without loss, but with gain. In the last chapter we find, as a substitute for the Ostwald theory of indicators, one based upon "thermochemical data and the hydrolysis of salts in solution" and having "its origin in the principles set forth by Berthelot in his *Thermochimie*" (p. 167). We read here that the change of color of an acid indicator is due to the difference in color between the free acid and its alkaline salt.

On page 127 we read: "If the contradictions between the facts and the theory of ionization appear to require the rejection of the latter, one falls then into another difficulty, that of not explaining the necessity of introducing the coefficient i into the general law of equilibrium of Guldberg and Waage." The author thinks, however, that the molecular

association of liquids and its working in the case of salt solutions, together with the hydrolysis idea as set forth by Reychler, fully suffice to explain the chemical peculiarities of salt solutions. ". . . The two parts into which a salt dissolved in water ought necessarily to separate in order to produce a double decomposition, are not hypothetical electrical ions, but a *real* base and acid coming from the chemical action of water upon the salt in solution" (p. 133).

It would be of little use to undertake here to defend the dissociation theory. Besides, one would mostly have to repeat what was written on various occasions, during the storm and stress period of the theory, by Ostwald's powerful pen. Thus, referring to Reychler's hydrolysis idea, Ostwald pointed out in 1893: "Unfortunately, the author has omitted to state how his hypothesis works in the case of salts of insoluble acids or bases; how, for instance, 50 to 80 per cent. of zinc hydroxide can remain dissolved, without precipitating out, in a solution of zinc sulphate or zinc chloride."[1] It might also be asked, why a strong solution of common salt, if it contains a great deal of free hydrochloric acid, does not invert ordinary cane sugar, and so forth, and so forth. But we will not insist.

The best friends of the dissociation theory have come to feel that it is insufficient, that it needs modification, or rather, perhaps, some addition. But its quantitative triumphs have been remarkable. *It will not go unless some new theory is brought forward that will do all that the dissociation theory has done, and more, and that on a quantitative basis, in the way of correlating apparently disconnected phenomena.*

Chesneau's book contains no such new theory, and its blow at the dissociation idea will scarcely be felt. Nevertheless, its contents will be of interest to research students of the theory of solutions. It certainly is well written, well translated by Professors Lincoln and Carnahan, and beautifully published by the Macmillan Company.

M. A. Rosanoff

[1] See *Zeit. physik. Chemie*, XII., p. 800, 1893.

SCIENTIFIC JOURNALS AND ARTICLES

The recent numbers of the *Journal of Pharmacology and Experimental Therapeutics* contain the following articles:

Vol. I., No. 5.

"Anastomosis between the Portal Vein and the Inferior Vena Cava (Eck's Fistula,)" by B. M. Bernheim, John Homans and Carl Voegtlin.

"The Pharmacologic Action of Certain Protein Cleavage Products upon the Heart," by R. B. Gibson and W. H. Schultz.

"The Influence of Alcohol on the Composition of the Urine," by W. Salant and F. C. Hinkel.

"A Poisonous Principle in Certain Cotton-seed Meals," by Albert C. Crawford.

"Physiological Studies in Anaphylaxis: I., The Reaction of Smooth Muscle of the Guinea-pig Sensitized with Horse Serum," by W. H. Schulz.

Proceedings of the American Society of Pharmacology and Experimental Therapeutics.

Vol. I., No. 6.

"An Experimental Study of the Functional Activity of the Kidneys by Means of Phenolsulphonephthalein," by L. G. Rowntree and J. T. Geraghty.

"A Practical Method for the Preparation of Phenolsulphonephthalein," by Edgar A. Slagle.

Vol. II., No. 1.

"The Action of Drugs on the Salivary Secretion," by V. E. Henderson.

"Thyreotropic Iodine Compounds," by Reid Hunt and Atherton Seidell.

"On Insufflation of the Lungs with Hydrogen; with Carbon Dioxide, and with Air," by C. C. Guthrie, F. V. Guthrie and A. H. Ryan.

"The Influence of Intravenous Injections of Sparteine and Adrenalin on the Heart of the Dog," by A. Strickler and Moyer S. Fleisher.

"In regard to the Detoxification of Benzoic Acid by Optical Isomers of Leucin," by A. H. Koelker and Samuel Amberg.

"On the Toxicology of the Tutu Plant," by W. W. Ford.

Vol. II., No. 2.

"On the Action of Magnesium Sulphate," by S. A. Matthews and Clyde Brooks.

"On the Efficacy of Antimony-thioglycollic Acid Compounds in the Treatment of Experimental Trypanosomiasis," by John J. Abel and L. G. Rowntree.

"Further Observations on the Immunization of Animals to the Poisons of Fungi," by W. W. Ford.

"Expectorants," by V. E. Henderson and A. H. Taylor.

SPECIAL ARTICLES

ELLIPTIC INTERFERENCE IN CONNECTION WITH REFLECTING GRATING

IN my earlier papers[1] and in a forthcoming theoretical account of the subject, I have shown the practical advantages obtained by associating the interferences of thin plates with the diffractions of the transparent grating—a subject originally suggested to me by the phenomenon of coronas, in which a marked interference phenomenon was also superposed on the diffractions. These elliptic fringes may, however, be evoked in other ways than those discussed, and it is to some of these that I venture to refer here.

Let the oblique mirror in Michelson's apparatus, for instance, be the usual plate of glass and replace the two opaque mirrors M and N by identical small reflecting gratings, set at the angle of diffraction of the spectrum, symmetrically to the incident rays. Here the elliptic interferences will be seen in the telescope at right angles to the rays issuing from the collimator. This adjustment is virtually the same as the plan of returning the diffracted spectra normally to the oblique transparent grating, discussed in the preceding paper in this JOURNAL. The fringes are rings.

Again, in a simple spectrometer adjustment for grating spectra, suppose the grating (either transmitting or reflecting) to be separated into two halves by a division parallel to the ruling. Then on displacing one of the halves, micrometrically, parallel to itself from its original coplanar position, elliptic interference must show itself in a way which is perhaps more direct than any of the methods hitherto treated. The fringes are straight.

CARL BARUS

BROWN UNIVERSITY, R. I.

THE AMERICAN SOCIETY OF NATURALISTS

THE twenty-eighth annual meeting of the American Society of Naturalists was held in the auditorium of the New York State College of Agriculture at Cornell University on December 29 and 30. The eastern branch of the American Society of Zoologists so arranged its program that members were enabled to attend the Naturalists' meeting. Many of the members of the Association of Anatomists and American Society of Bacteriologists which were meeting in Ithaca also attended the program. Although the Botanical Society of America met elsewhere a number of botanists came instead to the meetings of the Naturalists. It may fairly be said, judging from the number present at both sessions, that the Naturalists' symposium was the chief feature of general interest at the entire Ithaca meetings.

The one cause of general regret was the unavoidable absence of the president, Dr. D. T. MacDougal, who was ill in the Johns Hopkins Hospital. President MacDougal had so carefully planned the program and had done so much to instill enthusiasm into the entire arrangements that all felt the pronounced success of the occasion to be the result of his efforts.

Dr. MacDougal's well-thought-out and richly suggestive address on "Organic Response" was read at the annual dinner of the society by the vice-president, Professor H. S. Jennings.

At the meeting of the executive committee and at the business session of the society there was a general expression of the feeling that the present affiliation of the biological societies was highly desirable. The Anatomists, Bacteriologists, Zoologists and Naturalists which met at Ithaca might meet comfortably at many of the universities of the country which are situated, as Cornell is, in a small town. It was also felt that there was a far more favorable opportunity for personal discussions and exchange of ideas at a smaller meeting than at a more general one.

The Anatomists, Zoologists and Naturalists had a joint smoker at the Ithaca Hotel on Wednesday evening.

The Naturalists' dinner was given on the following evening at the Ithaca Hotel and was well attended. After the dinner the president's address was read.

The scientific program was given on Thursday afternoon and on Friday both fore- and afternoon.

The central topic of the discussions was the pure line conception in the study of inheritance and evolution. Most of the papers in the first part of the program seemed to support the views of Professor Johannsen, while several of the later papers on the program seemed to strongly suggest that selection and a modified Lamarckian view were yet to account for important factors in the

[1] SCIENCE, XXXII., 1910, p. 92; *Am. Journal of Science*, XXX., 1910, p. 161.

production of new species. The valuable feature of the program was the forcible way in which the opposing evidence and ideas of species formation were presented by the several participants. Professor Johannsen, of Copenhagen, who has so strikingly expounded the principles of pure lines and genotypes in the study of inheritance, sent a most suggestive paper to be read before the symposium.

PUBLICATION OF PAPERS

The address of the president and all papers read before the society will appear in series in the forthcoming numbers of *The American Naturalist*.

The importance and scope of the papers read are shown by the following titles:

H. J. Webber, Cornell University, "What is a Genotype or Biotype?"

H. S. Jennings, Johns Hopkins University, "Pure Lines in the Study of Genetics in Lower Organisms."

E. M. East, Bussey Institute, "The Genotype Hypothesis and Hybridization."

W. Johannsen, University of Copenhagen, "The Genotype Conception of Heredity."

Geo. H. Shull, Carnegie Institution, "The Genotypes of Maize."

T. H. Morgan, Columbia University, "The Application of the Conception of Pure Lines to Sex-limited Inheritance and to Sexual Dimorphism."

J. Arthur Harris, Carnegie Institution, "The Biometric Proof of the Pure Line Theory."

R. A. Emerson, University of Nebraska, "Some Genetic Correlations in Maize and their Relation to the Formation of New Genotypes through Hybridization."

R. Pearl, Maine Agricultural Experiment Station, "The Inheritance of Fecundity in the Domestic Fowl."

W. E. Castle, Harvard University, "Are Unit Characters Subject to Modification by Selection?"

F. B. Sumner, United States Fisheries, "Some Effects of Temperature upon Growing Mice and the Persistence of such Effects in a Subsequent Generation."

J. H. Gerould, Dartmouth College, "Polymorphism and Inheritance in *Colias Philodice*."

S. Hatai, Wistar Institute, "On the Mendelian Ratio and Blended Inheritance."

M. F. Guyer, University of Cincinnati, "The Nucleus and Cytoplasm in Inheritance."

Many of the papers were followed by interesting discussion, but unfortunately the program proved to be too long to allow full time for this desirable feature.

Several valuable demonstrations were displayed by members of the society.

NEW MEMBERS

The following were elected members of the Naturalists: J. F. Abbot, Washington University; R. A. Emerson, University of Nebraska; A. W. Gilbert, Cornell University; L. Griggs, Dartmouth College; A. Gulick, University of Toronto; J. A. Harris, Carnegie Institution; S. Hatai, Wistar Institute; H. E. Jordan, University of Virginia; A. E. Lambert, Massachusetts State Normal School; C. C. Little, Bussey Institute; H. H. Love, Cornell University; S. O. Mast, Goucher College; G. T. Moore, Washington University; J. C. Phillips, Bussey Institute; R. E. Sheldon, University of Pittsburgh; A. F. Shull, Columbia University; W. J. Spillman, U. S. Department of Agriculture; H. B. Torrey, University of California; G. Wagner, University of Wisconsin; H. J. Webber, Cornell University; E. N. Wentworth, Iowa State College; D. D. Whitney, Wesleyan University.

The following officers were elected for 1911:

President—Professor H. S. Jennings, Johns Hopkins University.

Vice-president and Chairman of Eastern Branch—Dr. Geo. H. Shull, Carnegie Institution.

Treasurer—Professor E. M. East, Bussey Institute.

Secretary—Professor C. R. Stockard, Cornell University Medical School.

Additional Members of Executive Committee—Professor W. L. Tower, University of Chicago, and Dr. B. M. Davis, Cambridge, Mass.

CHAS. R. STOCKARD,
Secretary

THE AMERICAN CHEMICAL SOCIETY

THE forty-third general meeting of the American Chemical Society, held at Minneapolis, December 28–31, was attended by 275 members and guests and, like all recent meetings of the society, was simply an echo of the general enthusiasm that pervades its membership.

Owing to the fact that over 175 papers were presented, it was necessary to hold meetings of all of the divisions and the meetings of the Division of Agricultural and Food Chemistry, Division of Fertilizer Chemistry, Division of Pharmaceutical Chemistry, Division of Industrial Chemists and Chemical Engineers, Division of Physical and Inorganic Chemistry and Division of Organic Chemistry, were well attended.

A point especially worthy of note was the

success of the Biological Section under the chairmanship of Dr. Carl L. Alsberg, of Washington, D. C. Forty-four papers were presented before this section of a strictly chemical nature bearing upon biochemical problems.

The meeting of the Section of Chemical Education, held at a time when all the industrial chemists could meet with them, proved decidedly interesting and the discussion was general.

On the first day of the meeting the chemists all gathered in general session to listen to eight general addresses as follows:

"The Lost Arts of Chemistry," W. D. Richardson.

"The Basis of Industrial Efficiency," A. D. Little.

"Synthetic Metals from Non-metallic Elements," Herbert N. McCoy.

"Progress in Food Chemistry," H. E. Barnard.

"Mechanism of Cell Activity," Carl L. Alsberg.

"Waste Wood and some of its By-products," Geo. B. Frankforter.

"The Formation of Carbohydrates in the Vegetable Kingdom," Wm. McPherson.

"The Efficiency of the College Graduate in the Chemical Industry," Chas. F. Burgess.

The address of the retiring president, Wilder D. Bancroft, on "A Universal Law," was an exposition of the general application of the theorem of LeChatelier to all kinds of natural phenomena as well as those of a chemical nature.

Possibly the complimentary smoker in the rooms of the Commercial Club was as thoroughly enjoyed as any one feature of the meeting, for an unusually witty program had been arranged and original songs bearing upon individual chemists and chemical phenomena were thoroughly enjoyed; also the mementoes furnished to the visiting chemists were pleasing to all. This, however, was not the only social function of the meeting, for several receptions and teas were arranged for the ladies and the banquet on Friday night, which was attended by some two hundred members, was also graced by their presence.

Excursions to the following places and works were taken by the members: Russell-Miller Milling Co., Pillsbury Flour Mills Co., Washburn-Crosby Co., Consolidated Milling Co., Minnesota Linseed Oil and Paint Co., Archer-Daniels Co., Midland Linseed Oil Co., St. Anthony Falls Water Power Co., Cream of Wheat Co. and International Stock Food Co.

On Saturday afternoon a large number were treated to a sight-seeing trip covering both the cities of Minneapolis and St. Paul. A number of the chemists also had the privilege of viewing the wonderful paintings of La Farge in the state capitol of Minnesota.

The announcement of the election of Alexander Smith as president of the society and of Louis Kahlenberg, Frank K. Cameron, Geo. B. Frankforter and E. C. Franklin and E. G. Love as councilors-at-large met with hearty approval and applause.

M. C. Whitaker was elected editor of the *Journal of Industrial and Engineering Chemistry*, and the report of a committee recommending a decided broadening of the policy of that journal was adopted.

The secretary announced a net gain of 550 members for the year, the society now having a membership of over 5,100.

CHARLES L. PARSONS,
Secretary

THE TWENTY-THIRD ANNUAL MEETING OF THE AMERICAN PHYSIOLOGICAL SOCIETY, NEW HAVEN, CONN., DECEMBER 27–30, 1910

FOR the first time in many years the physiologists of the country, together with the biochemists and the pharmacologists, met apart, not only from the American Association for the Advancement of Science, but also from the group of societies associated with the naturalists. Sixty-three of the society's one hundred and seventy-five members were present. The meeting was successful in point of attendance as well as in the number of communications of high merit and in able discussions. An important factor in the success of the meeting was the splendid arrangements made for us by the local committee (the biologists of the Sheffield Scientific School, the Yale Medical School and the Connecticut Agricultural Experiment Station) and the cordial hospitality extended by this committee to the visiting members.

The following papers and demonstrations were presented and discussed during the six scientific sessions (two of these being joint sessions with the biological chemists).

E. B. Meigs, "The Osmotic Properties of Smooth Muscle."

Gertrude F. Barbour and P. E. Stiles, "Localized Activity in Skeletal Muscle."

C. J. Wiggers, "Pulse Pressure Variations in the Pulmonary Circuit."

G. W. Fitz, "A Preliminary Report of Work

with the Shadow Pupillometer in Determining the Constants of Pupillary Reactions."

G. H. Parker, "The Olfactory Sense in Fishes."

F. C. Becht and A. B. Luckhardt, "On the Source of the Immune Bodies in the Lymphs."

J. R. Murlin and J. R. Greer, "The Heart Action in Relation to the Respiratory Metabolism."

W. B. Cannon and C. W. Leib, "The Receptive Relaxations of the Stomach."

S. Simpson, "Are the Parathyroids Capable of Replacing the Thyroids Physiologically?"

L. Loeb, "The Function of the Corpus Luteum."

T. B. Osborne and L. B. Mendel, "Feeding Experiments with Mixtures of Isolated Food Substances."

Elizabeth Cooke and S. P. Beebe, "Autolysis of Liver as Affected by Thyroid Administration."

J. Loeb, "Further Experiments on the Antagonistic Action of Salts."

O. Schreiner and M. X. Sullivan, "Biological Analogies in Soil Oxidation."

S. J. Meltzer, "The Migration of Solutions in Animal Bodies Deprived of their Cardiac Circulation."

G. N. Stewart, "Measurement of the Blood Flow in Man."

W. H. Howell, "The Action of Pure Thrombin."

G. W. Fitz, "A Shadow Pupillometer for the Accurate Study of Pupillary Reactions."

S. Simpson, "A Modification of Schäfer's Frog-heart Plethysmograph."

Y. Henderson, "A Quantitative Pneumograph."

E. D. Jackson, "An Automatic Shellacking Device."

A. J. Carlson, "The Mechanisms of Automaticity, Coordination and Conduction in the *Limulus* Heart." (Demonstration.)

A. B. McCallum, "Some Illustrations in Animal and Vegetable Cells of the Gibbs-Thomson Law of Surface Condensation of Solutes."

H. Cushing, E. Goetsch and C. Jacobson, "The Hypophysis and its Relation to Carbohydrate Tolerance."

H. C. Jackson, "Changes in the Blood and Tissues following Double Nephrectomy and Urethral Ligation."

J. Auer, "The Causation of Acute Anaphylactic Death in the Rabbit."

J. R. Murlin and L. H. Mills, "The Influence on Metabolism of Oils given Subcutaneously and Intravenously."

A. B. Luckhardt and F. C. Becht, "The Relation of the Spleen to the Fixation of Antigens and the Production of Immune Bodies."

P. A. Grant, Elanor Van Alstyne and S. P. Beebe, "The Absorption of Protein through the Intact Intestinal Epithelium."

F. Wills and P. B. Hawk, "The Stimulation of the Gastric Secretion under the Influence of Water-drinking with Meals."

V. E. Henderson, "The Effect of Temperature upon the Heart."

J. S. Miller, D. D. Lewis and S. A. Matthews, "The Effects of the Intravenous Injection of Extracts of the Different Parts of the Hypophysis."

W. B. Cannon, "Observations on the Nature of Gastric Peristalsis."

F. H. Pike, "The Mechanism of the Asphyxial Rise of Blood Pressure in the Spinal Animal."

J. A. E. Eyster, "The Effects of the Intravenous Injection of Extracts of the Pineal Body."

D. R. Joseph and S. J. Meltzer, "Inhibition of the Duodenum Coincident with the Movements of the Pyloric Part of the Stomach."

A. J. Carlson, J. R. Rooks and J. R. McKie, "Attempts to Produce Experimental Hyperthyroidism in Different Animal Groups" (with demonstrations).

Owing to the absence of the authors the following papers were read by title only:

W. Koch and C. C. Todd, "The Nature of the Chemical Combinations of Potassium in the Tissues."

A. Hunter and M. H. Givens, "The Allantoin and Purin Metabolism in the Monkey."

T. G. Brodie, "The Gaseous Metabolism of the Heart."

G. Lusk, "A Method of Removing the Glycogen in the Human Subject."

P. B. Hawk, "The Activity of the Pancreas during Moderate and Copious Water Drinking with Meals."

W. M. Hattrem and P. B. Hawk, "On the Intestinal Putrefaction during Copious and Moderate Water-drinking with Meals."

Clara Jacobson, "On the Mechanisms of Inhibition of the Parathyroid Tetany in Mammals by Calcium Salts."

W. Jones, "A Specific Nuclease for Guanylic Acid."

The society appropriated $100 to the *American Journal of Physiology* towards defraying the cost of the index volume.

The following new members were elected:

Harvard University: J. H. Pratt, W. J. V. Osterhaut, A. Forbes.

University of California: T. B. Robertson, S. S. Maxwell.

Washington University: W. E. Garrey, D. E. Jackson.

University of Pittsburgh: C. Brooks, R. E. Sheldon.

Cornell University: J. R. Greer, E. Sachs, J. F. McClendon.

Columbia University: W. G. MacCallum.

Western Reserve University: D. Marine.

Yale University: L. L. Woodruff.

The following officers were elected for the year 1911:

President—S. J. Meltzer.

Secretary—A. J. Carlson.

Treasurer—W. B. Cannon.

Members of the Council—J. Erlanger, F. S. Lee.

A. J. CARLSON,
Secretary

UNIVERSITY OF CHICAGO

THE AMERICAN MATHEMATICAL SOCIETY

THE seventeenth annual meeting of the American Mathematical Society was held at Columbia University on Wednesday and Thursday, December 28–29, 1910, extending through the usual morning and afternoon sessions on each day. Sixty-two members were in attendance. President Maxime Bôcher took the chair at the opening session, yielding it to Professor Kasner, Ex-president Osgood, and at the morning session on Thursday to the president-elect, Professor H. B. Fine. The council announced the election of the following persons to membership in the society: Professor Percy Hodge, Columbia University; Mr. C. G. P. Kuschke, University of California; Professor Marion B. White, University of Kansas. Eight applications for membership in the society were received.

On Wednesday evening thirty of the members gathered at the annual dinner, which has for many years been a pleasant adjunct to the regular sessions.

It was decided to hold the summer meeting of the society at Vassar College in 1911, and at the University of Pennsylvania in 1912. A committee, consisting of Professors H. S. White, P. F. Smith and the secretary, was appointed to make the necessary arrangements for the summer meeting of 1911.

At the annual election, which concluded on Thursday morning, the following officers and other members of the council were chosen:

President—Professor H. B. Fine.

Vice-presidents—Professors G. A. Bliss and W. E. Story.

Secretary—Professor F. N. Cole.

Treasurer—Professor J. H. Tanner.

Librarian—Professor D. E. Smith.

Committee of Publication—Professors F. N. Cole, E. W. Brown and Virgil Snyder.

Members of the Council (to serve until December, 1913)—Professors H. F. Blichfeldt, J. L. Coolidge, C. J. Keyser and J. W. Young.

The total membership of the society is now 642, including 60 life members, an increase of 24 during the past year. The total attendance at all meetings of the year was 317; the number of papers presented was 145; 202 votes were cast at the annual election. The treasurer's report shows a balance of $8,124.53, a slight increase over last year, although the university subventions for the *Transactions*, amounting to $500 per annum, have been discontinued and the society has paid an installment of 1,000 francs of its contribution toward the publication of the works of Euler. The income from sales of the society's publications during the year was $1,660.21. The life-membership fund now amounts to $3,901.83. The library shows the normal increase, the total number of books on the shelves being now 3,508.

During the past sixteen years the society has expended for printing the *Bulletin*, *Transactions* and other publications $42,473.57. The total returns from publications have been in the same period $15,375.20. The stock of publications on hand may be fairly valued at about $10,000. The university subventions have amounted to $8,100. Editorial and administrative expenses during the sixteen years have been $11,739.14. The society is about to undertake the publication of the Princeton Colloquium Lectures and the republication of Klein's Evanston Lectures.

The following papers were read at the annual meeting:

S. Chapman: "A note on the theory of summable integrals."

H. H. Mitchell: "Concerning a rotation group in six-space."

Virgil Snyder: "An application of a (1–2) quaternary correspondence."

A. S. Hawkesworth: "Three new dimension theorems."

W. R. Longley: "Singular points on the discriminant locus of an ordinary differential equation."

R. G. D. Richardson: "Theorems of oscillation for two self-adjoint linear differential equations of the second order with two parameters."

Maxime Bôcher: "A simple proof of a funda-

mental theorem in the theory of integral equations."

J. L. Coolidge: "The metrical aspect of the line-sphere transformation."

E. J. Miles: "The absolute minimum of a definite integral in a special field."

J. C. Fields: "A method of proving certain theorems relating to rational functions which are adjoint to the fundamental algebraic equation for a given value of the independent variable."

F. F. Decker: "On the order of a restricted system of equations."

Paul Saurel: "On the classification of crystals."

A. B. Coble: "An application of Moore's cross ratio group to the solution of the sextic equation."

A. B. Coble: "The cubic surface and plane six-point."

C. L. E. Moore: "Conjugate directions on a hypersurface in S_4 and some allied curves."

W. H. Bates: "An application of symbolic methods to the treatment of mean curvature in hyperspace."

H. B. Phillips: "The Galois theory of sets of multipartite variables."

J. R. Conner: "Correspondences associated with the rational plane quintic curve."

L. P. Eisenhart: "Conjugate systems and envelopes of spheres."

Joseph Lipke: "Natural families of curves in a general curved space of n dimensions."

O. E. Glenn: "On the discriminants of ternary forms."

Professor Bates's paper will appear in full in the January *Transactions*. Abstracts of the other papers will be included in the secretary's report in the March number of the *Bulletin*.

The Chicago Section of the society held its twenty-eighth regular meeting at the University of Chicago, December 28–30. The next meeting of the society will be held at Columbia University on Saturday, February 25.

F. N. Cole,
Secretary

THE SOUTHERN SOCIETY FOR PHILOSOPHY AND PSYCHOLOGY

The sixth annual meeting of the Southern Society for Philosophy and Psychology was held at Chattanooga, Tenn., December 27 and 28, 1910. The meetings were presided over by Professor Edward Franklin Buchner, who delivered the presidential address on the topic: "Learning and Forgetting."

The following papers and reports were read:

Thomas P. Bailey, New York Bureau of Municipal Research, "Some supposed Racial Tendencies of the American Negro: A Plea for a Psychological Study of the Race Problem."

Jasper C. Barnes, Maryville College, "The Pressure Curve in Voluntary Control."

Knight Dunlap, Johns Hopkins University, "A Study in Rhythm Perception."

David Spence Hill, Peabody College for Teachers, (*a*) "Some Needs for Child Welfare in the South," (*b*) "Class and Practise Experiments," (*c*) "A Comparative Study of Children's Ideals."

A. J. McKelway, secretary, National Child Labor Committee for the Southern States, "Child Labor in its Relation to Education."

R. M. Ogden, University of Tennessee, (*a*) "The Order of the Days of the Week and the Pythagorean Philosophy," (*b*) "Knowing and Expressing."

Jno. Pickett Turner, Vanderbilt University, "Locke's Place in the History of Thought."

Tom A. Williams, Washington, D. C., (*a*) "The Modern Interpretation of Dreams and Visions, Sleeping and Waking," (*b*) "Intellectual Precocity: The Rôle of the Inclinations and Affectivity: A Comparison of the Principles and Methods employed for educating John Stuart Mill and Boris Sidis's Son."

The officers elected for the year 1911 are:

President—Dr. Shepherd Ivory Franz, Government Hospital for the Insane; *Vice-president*—Professor A. Caswell Ellis, University of Texas.

Secretary-treasurer—Professor R. M. Ogden, University of Tennessee.

Vacancies in the council were filled to constitute that body as follows: for a three-year term, Professors E. F. Buchner, Johns Hopkins University, and W. B. Smith, Tulane University; for a two-year term, Professor Bruce R. Payne, University of Virginia, and President H. J. Pearce, Breneau College; for a one-year term, Professors David Spence Hill, Peabody College for Teachers, and W. C. Ruediger, George Washington University.

It was voted to hold the next meeting of the society at Washington, D. C., in affiliation with the American Association for the Advancement of Science, provided the American Psychological and Philosophical Associations meet at the same place and time.

R. M. Ogden,
Secretary